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IGR transliteration of Russian

The AGI Translation Office has adopted the essential features of Cyrillic transliteration recommended by the U. S. Department of the Interior, Board on Geographic Names, Washington D. C.

However, the AGI Translation Office recommends the following modifications:

1. Ye initially, after vowels, and after "ъ, ь" Customary usage calls for "ie" in many names, e. g., SOVIET KIEV, DNEPER, etc.; or "ye", e. g., BYELORUSSIA, where "e" follows consonants. "e" with dieresis in Russian should be given as "yo".
2. Omitted if preceding a "y", for example, Arkhangelsky (not "iy"; not "ii").
3. Generally omitted.

NOTE: Well-known place and personal names that have wide acceptance will be used. Some translations may include elements of previous German transliteration from the Russian; this occurs in IGR most commonly in maps and lists of references. The reader's attention is called to the following variations between German and English systems which may cause confusion when trying to check back to original Russian sources.

Alphabet		transliteration
А	а	a
Б	б	b
В	в	v
Г	г	g
Д	д	d
Е	е	e, ye ⁽¹⁾
Ё	ё	ë, yë
Ж	ж	zh
З	з	z
И	и	i ⁽²⁾
Й	й	y
К	к	k
Л	л	l
М	м	m
Н	н	n
О	о	o
П	п	p
Р	р	r
С	с	s
Т	т	t
У	у	u
Ф	ф	f
Х	х	kh
Ц	ц	ts
Ч	ч	ch
Ш	ш	sh
Щ	щ	shch
Ъ	ъ	" ⁽³⁾
Ы	ы	y
Ь	ь	; ⁽³⁾
Э	э	e \
Ю	ю	yu
Я	я	ya

German	English
w	v
s	z
ch	kh
tz	ts
tsch	ch
sch	sh
schtsch	shch
ja	ya
ju	yu

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METASOMATIC ZONALITY AND GENESIS OF SAPPHIRINE-BEARING ROCKS IN THE BUG REGION, by E. B. Nalivkina.

MINERALOGY OF WEATHERED BASALT CRUST IN WEST VOLYNIA, by V. P. Shashkina.

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SEISMOLOGY IN THE U. S. S. R., by Peter Dehlinger.

THE ROLE OF METASOMATISM IN THE FORMATION OF ALKALINE ROCKS¹

by

Ye. L. Butakova²

• translated by Royer and Roger, Inc. •

ABSTRACT

Various processes of metasomatism, such as biotitization, aegiritization, and nephelinization, control the ultimate appearance of rocks just as much as magmatic stages of their development. These processes have been brought to light in small composite intrusions in the northern part of the Siberian shield. The aegiritization and nephelinization reconstitute melanocratic rocks with non-alkaline pyroxene into mesocratic rocks with alkaline pyroxene. Of great interest is the conversion of dolerite at the contact with an alkaline intrusion into a rich nepheline rock, which retains vestiges of a poikilophitic texture. The investigation showed that metasomatism is involved in formation of alkaline rocks. Such rocks as carbonates were evidently formed here through the metasomatism of alkaline and nepheline syenite. --- Auth.

Despite the wide acceptance of the ideas of metasomatism over the last ten years, the best monographs in this country on alkaline intrusions sometimes underrate the role of metasomatic processes in the formation of alkaline rocks. The recently published articles of S. Borodin (1957) and others are among the few which give due regard to the processes of metasomatism in alkaline rocks.

From the example of alkaline intrusions in the north Siberian platform, the author was forced to draw the conclusion that contact metasomatism is usually associated with very intensive and varied manifestations of "autometasomatism" in intrusive alkaline rocks. These changes commonly condition the ultimate appearance of the rocks just as much as the magmatic stages of their development.

The aim of this article is to acquaint readers with a number of interesting facts regarding the development of metasomatism in alkaline rocks.

Along the watershed of the Maymecha and Kotuy Rivers there are several alkaline massifs (with an outcrop area of 0.1 to 0.5 to 2 square kilometers) embedded in limestones and dolomites of the Middle Cambrian. The intrusions have almost oval sections at the surface and appear to be block-like or funnel-shaped bodies. The intrusions belong to the ultrabasic and alkaline complex of the north Siberian platform (Butakova, 1956) and, having been formed during the initial phases of the magmatic activity causing

the complex, are probably early Mesozoic in age. They are mainly composed of non-feldspar alkaline rocks, among which melteigite, ijolite-melteigite and ijolite predominate. The nepheline and alkaline syenites and melilite-rich alkaline rocks are less important. The massifs are complex intrusions which have been formed in the course of several intrusive phases.

The intrusive contacts studied make it possible to single out three phases in the appearance of non-feldspar alkaline rocks: 1) the phase during which there is formation of ijolite, melteigite and jacupirangite with pyroxene (aegirite-augite or aegirite-diopside) poor in aegirite; 2) the phase during which there is formation mainly of ijolite and melteigite with pyroxene comparatively rich in aegirite, and 3) the vein micromelteigite phase. These are followed by the intrusion of nepheline syenite and, presumably, alkaline syenite. The period and nature of genesis of the melilite-rich rocks are not clear. The enclosing carbonate rocks are greatly metamorphosed at the narrow contacts with the formation of magnesite, olivine, spinel, phlogopite, diopside, tremolite and other minerals.

The metasomatic processes of biotitization, aegiritization, apatitization, nephelinization, cancrinitization, zeolitization, albitization and carbonatization were widely and variously developed in the intrusive rocks. We can establish the sequence of most metasomatic changes in the intrusions, and link them with certain phases of intrusive activity.

The earliest process is biotitization, which is associated with the first phase of formation of non-feldspar alkaline rocks. The second phase of development of rocks of this composition is associated with apatitization, aegiritization and nephelinization. Cancrinitization, carbonatization, zeolitization, and albitization, i. e., relatively low-temperature metasomatic

¹Translated from *O roli metasomatoza v obrazovanii melchokhnykh porod*: Mineralogicheskyy sbornik, Leningradskogo geologicheskogo obshchestva, no. 13, 1959, p. 282-290.

²Leningrad Research Institute of Arctic Geology.

processes, were particularly manifested in the newer rocks—the nepheline and alkaline syenites—and, to all appearances, are mainly associated with the final stages of magmatism.

The metasomatic development of biotite occurs at first at the pyroxene and nepheline grain boundaries. Later on numerous lenticular veins and irregular concentrations of fine-flaked mica appear in the rocks.

The enrichment of rock with apatite and the nephelinization of melanocratic basically aegirite-augite rocks (jacupirangite and alkaline pyroxenite) is much the same. The nepheline forms a large number of thin veins (0.1 to 0.2 millimeters) with wavy boundaries between grains and inside the pyroxene grains (fig. 1).

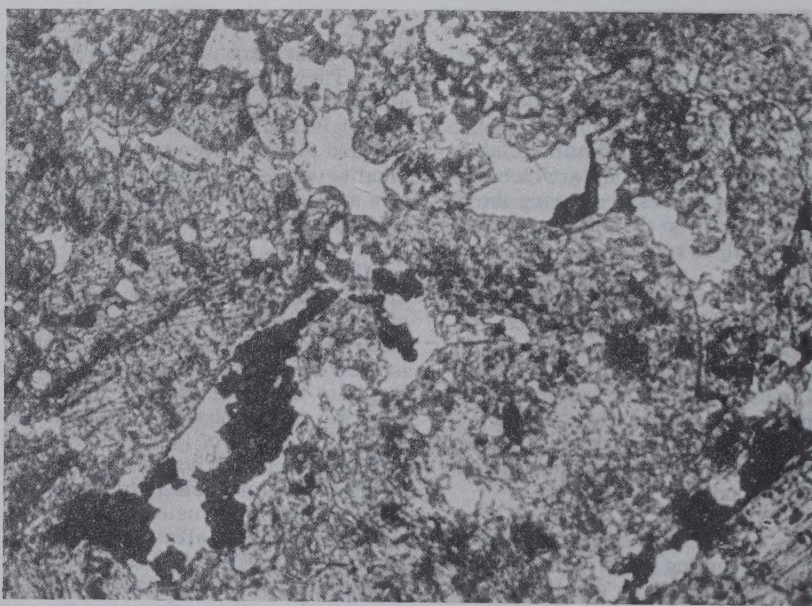


FIGURE 1. Nephelinization of jacupirangite. Nepheline in irregular lenticular veins with ore minerals, sphene and biotite. Without analyzer. 20X.

We should describe in greater detail the aegiritization of originally aegirite-poor aegirite-augite and aegirite-diopside, and also other observations showing the frequent metasomatic development of pyroxene in alkaline rocks. The aegiritization of pyroxene in alkaline rocks undergoing the first phase of magmatism is associated with numerous veins of rocks of the second intrusive phase. Even at the contact of the thinner veins pale greenish or pale yellowish-green pyroxene in the enclosing rock changes to light green or green aegirite-diopside, or aegirite-augite, no different in optical properties from the pyroxene of the vein rock. For example, pale greenish aegirite-diopside with $c: \gamma = 41-42^\circ$; $2V = +59-60^\circ$; $\gamma = 1.714$; $\alpha = 1.686$ is replaced by green aegirite-diopside with $c: \gamma = 60^\circ$; $2V = +71-72^\circ$; $\gamma = 1.734$; $\alpha = 1.706$. The width of these

contact zones is usually small, and is clearly a function of the thickness of the vein. If the thickness is from several to 10 centimeters, the width of the pyroxene aegiritization zone in the enclosing rock is 1 to 5 centimeters.

In many cases we observe that in the narrow endocontact zone in the vein rock (ijolite or melteigite) the elongated prismatic grains of pyroxene are arranged perpendicular or at large angles to the vein boundaries (figs. 2 and 3). The pyroxene in these contact zones does not differ in optical properties from the remaining pyroxene in the vein rock. It is most like the latter in shape and grain size. The development in these contact zones of more regular pyroxene grains with pointed facets is less common.

The arrangement of pyroxene grains perpendicular to the vein boundaries was also frequently observed in the contact areas of the ijolite and melteigite veins, which do not differ from the enclosing rocks in pyroxene content, but are usually more leucocratic and coarse-grained than the enclosing rock. These veins and lodes are very common in the intrusions investigated among non-feldspar rocks of both the first and second intrusive phases. It appears that these veins are due to the penetration of magma, differentiating on the spot (and postmagmatic solutions) into earlier solidified and cracked sections of the intrusion, and not to consecutive intrusive phases. In the finest veins of this kind (1 millimeter thick or less) the pyroxene grains generally lie across the vein with their ends supporting its edges (fig. 4).



FIGURE 2. Growth of prismatic grains of pyroxene in vein ijolite perpendicular to the contact contact surface. Without analyzer. 20X.

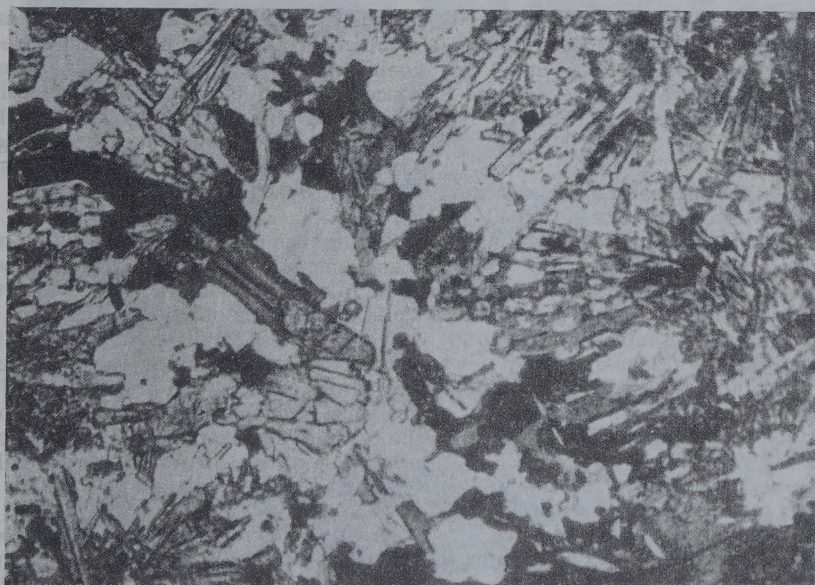


FIGURE 3. Radial and parallel spiky pyroxene aggregates along the contact in an ijolite vein. Without analyzer. 20X.

The development of radial aggregates of pyroxene is common alongside veins in enclosing rocks. It is occasionally possible to see bunches of pyroxene grains arranged along very fine cracks along the vein in the enclosing rock.

The enrichment of pyroxene in the enclosing rock in aegerite at the contact with the veins and the commonly observed orientation of pyroxene perpendicular to the vein boundaries show

the extent of metasomatism in the original magmatic injections.

Among the lower-temperature processes of metasomatism, carbonitization (which is always closely associated with cancrinitization, zeolitization and other metasomatic changes) deserves attention.

In the outer zone of the largest intrusions



FIGURE 4. Fine-grained melteigite vein in thin-grained melteigite. Prismatic pyroxene grains are common along vein. Without analyzer. 20X.

examined we observed aegirite-diopside-nepheline-calcitic rocks or ones with a more complex mineral composition, the common characteristic of which is a high calcite content, together with alkaline pyroxene and nepheline or potassium feldspar.

In the pyroxene-nepheline-calcite rocks (containing from 25 to 40 percent calcite, 25 to 40 percent nepheline, and 25 to 30 percent aegirite-diopside) the calcite is more xenomorphic ($\beta=1.658$). It corrodes and cements well-formed deposits of nepheline and pyroxene. The calcite in places forms grains of thin tablet-like habit which are very like laths of feldspar. It can only be assumed that they are complete pseudomorphs after feldspar, and that in this case the rock is carbonatized nepheline syenite.

Among the non-nepheline rocks containing potassium feldspar together with alkaline pyroxene and a considerable amount of calcite, attention should be given to formations classed by the author as alkaline syenite, but which are undoubtedly metasomatically altered rocks. These are medium-grained and fine-grained rocks with a variable quantity of all the principal minerals: 30 to 60 percent aegirite-diopside, 10 to 30 percent orthoclase, 8 to 25 percent apatite, 5 to 20 percent amphibole (semi-alkaline hornblende), and 2 to 10 percent (more rarely 20 percent) calcite. The colored minerals (aegirite-diopside with $\alpha=10^\circ$; $2V=-76^\circ$; $\gamma=1.756$; $\alpha=1.718$ and light green hornblende with a pale grayish lilac hue with respect to β , and the absorption pattern $\alpha>\beta>\gamma$, with $\gamma=18^\circ$, a large negative optic angle and $\gamma=1.650$; $\alpha=1.633$) form monomineral or

practically monomineral concentrations, in which concretions of a radial structure are common (fig. 5). The fine-grained apatite is concentrated in lenticular or completely irregular glomeroblastic concentrations. Here and there the concentrations merge into one network, the cells of which contain grains of colored minerals and potassium feldspar.

The extremely uneven distribution of all the main components, the direct replacement of some minerals by others, the development of radial aggregates of colored minerals, and the high apatite and calcite content are an indication of the great postmagmatic, metasomatic transformations of the rocks in question. The appearance of carbonate here is associated with the clearly metasomatic development of colored minerals and apatite, and is most likely a manifestation of metasomatism as well.

A close spacial association exists between the metasomatically altered alkaline syenites whose chief component is calcite ($\beta=1.658$; $\alpha=1.486$) making up to 30 to 50 percent of the volume. They also contain, to a lesser extent, aegirite-diopside (10 to 25 percent), potassium feldspar-orthoclase (5 to 30 percent) and other silicates (zeolite, phlogopite, biotite, albite and amphibole). These rocks exhibit a very uneven distribution of minerals with frequent development of their glomeroblast concentrations, while unequal grain size, an absence or underdevelopment of idiomorphic grains, and extensive replacement of earlier minerals (pyroxene and potassium feldspar) by later ones — mainly calcite and zeolite — is typical of the radial pyroxene concentrations. Complete fibrous

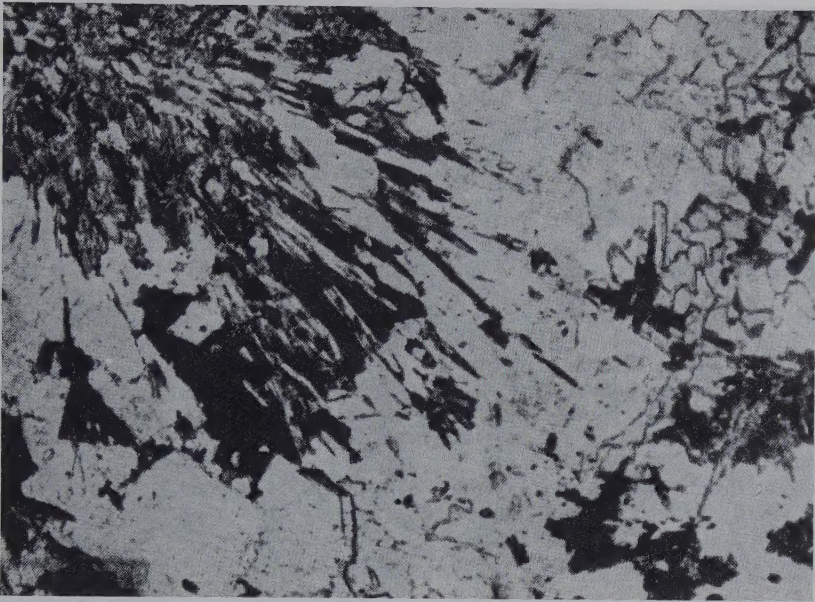


FIGURE 5. Radial pyroxene and amphibole aggregates in metasomatically altered alkaline syenite. Without analyzer. 20X.



FIGURE 6. Aegirite-diopside-feldspar-calcite rock (metasomatically altered alkaline syenite). Radial pyroxene aggregates can be seen in the photograph. Calcite is in tabular grains (gray). With analyzer. 20X.

zeolite pseudomorphs after nepheline are present.

All these characteristics taken together indicate the given rocks are mainly metasomatic or ones which have been greatly altered metasomatically.

The similarity between these rocks and the metasomatically altered alkaline syenites men-

tioned above in mineral composition, structure, and texture (and in certain types the gradual transition to syenites) suggest that they are metasomatically altered (carbonatized, zeolitized, phlogopitized and albitized) alkaline and nepheline syenites.

The calcium metasomatism of alkaline intrusive rocks is closely linked with the contact-metasomatic changes in the enclosing carbonate

deposits. By absorbing Si, Te, K, H₂O and other substances, which accompanied the alkaline magma intrusion, the carbonate sedimentary rocks (limestone and dolomite) were able to act as a source of Ca, Mg and CO₂ required for the changes taking place in the intrusive rocks.

Among the manifestations of contact metasomatism associated with alkaline intrusions, attention should be given to the changes in silicate host rocks observed in the contact aureole of the same large massif. Here, at a distance of 300 meters from the ijolite-melteigite exposures, we found an outcrop of comparatively slightly metamorphosed fine-grained dolerite with new basic plagioclase (labradorite nos. 59 and 60), and partially amphibolized augite. Normal green hornblende ($\gamma=18^\circ$; $2V=-68^\circ$) replaces the pyroxene around the periphery of the grain and along small cracks. In many places one grain of pyroxene is replaced by an aggregate of small rounded amphibole grainlets.

Brown lamellar biotite develops to a lesser extent. The primary poikilo-ophitic texture of the rock is quite clear.

Another rock was found 15 meters from the first in the direction of the ijolite-melteigite massif. It is an alkaline rock, whose principal minerals are nepheline, green aegirite-augite, brown hornblende and biotite. The nepheline (uniaxial, negative with $\beta=1.543 \pm 0.03$; $\gamma=1.539 \pm 0.003$, $\beta-\alpha=0.004$) in present in idiomorphic grains of unusual shape causing narrow, elongated, rectangular pits in the section. Deposits are sometimes to be found with two or three nepheline grains together, each of which has its own orientation, different from that of neighboring grains. In many cases they all vanish obliquely with respect to the boundaries of the deposit in which they occur.

The primary colored mineral in the rock is totally replaced by a fine-grained aggregate of aegirite-augite, brown hornblende and biotite. Concentrations of these minerals are located between the nepheline deposits. The middle sections of the aggregates retain relicts of green hornblende which has partially replaced the primary pyroxene in the dolerite of the neighboring outcrop. Despite its completely different mineral composition, the entire rock is extremely similar to amphibolized dolerite in its overall textural pattern. Elongated layers of idiomorphic nepheline are exactly the same in size and in relation to the plagioclase laths in dolerite (fig. 8). The shape of the grains, unusual for nepheline, and their oblique extinction, are indications of the pseudomorphic development of the nepheline, apparently after tabular plagioclase. Hence the texture of the alkaline biotite-amphibole-aegirite-nepheline rock is palimpsest after a poikilophitic texture, while the actual rock has evidently formed as a result of a meta-

somatic change in trap. The dolerite sills are found in the same carbonate rocks of the Middle Cambrian, the enclosing rocks for the alkaline intrusions. One of the sills seems to have been torn by the alkaline intrusion, and as a result of alkaline metasomatism the above-described alkaline rocks with palimpsest texture were formed at the contact.

In mineral composition these rocks are like melanocratic alkaline intrusions — melteigites. As they change, and as the relicts of ophitic texture vanish and the mineral composition becomes more simple through further replacement of the amphibole by alkaline pyroxene, essentially nepheline-pyroxene rocks arise, indistinguishable from rocks of the ijolite-melteigite series, which are common components of the rocks being considered. In the absence of the intermediate stages, (e.g., the two rock types studied by the author), the metasomatic origin of nepheline-pyroxene rocks becomes indeterminate and, being metasomatic formations, they have been mistaken, and in fact are still at times mistaken for intrusive rocks by certain investigators.

The observations made can be reduced to the following main conclusions:

1. Even in small intrusive bodies of alkaline composition, metasomatism is a common and varied manifestation. Its intensity increases towards the final phases of magmatic activity in complex multiphase intrusions, combined with an extension of the temperature range over which changes occur.

2. Only in the case of some mineral-forming processes, which show up most strongly in non-feldspar alkaline rocks of the first magmatic phase, can we establish their "superimposed" metasomatic nature (biotitization, apatitization).

Changes such as the metasomatic transformation of pyroxene and nephelinization may pass unnoticed during the final stages of development, since they do not alter the mineral composition of the rock qualitatively. The textural and structural characteristics produced by this development are usually more clearly defined at the initial stages and then become weaker and are sometimes "erased" during further development. It is therefore not out of the question that the role of metasomatism in the transformation of melanocratic intrusions into mesocratic and leucocratic ones, like the change from rock with nonalkaline pyroxene to one with pyroxene rich in aegirite, may actually be far greater than can be determined by direct observation.

In any case, observations convince us of the extremely frequent metasomatic development of pyroxene in intrusive bodies, and also prove the metasomatic enrichment of originally melano-

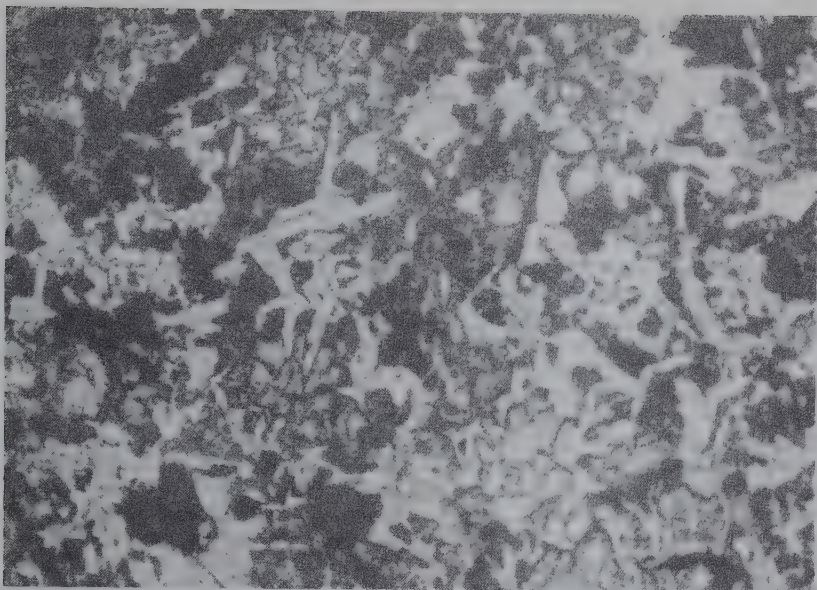


FIGURE 7. Amphibolized dolerite with poikilitic texture. Without analyzer. 20X.

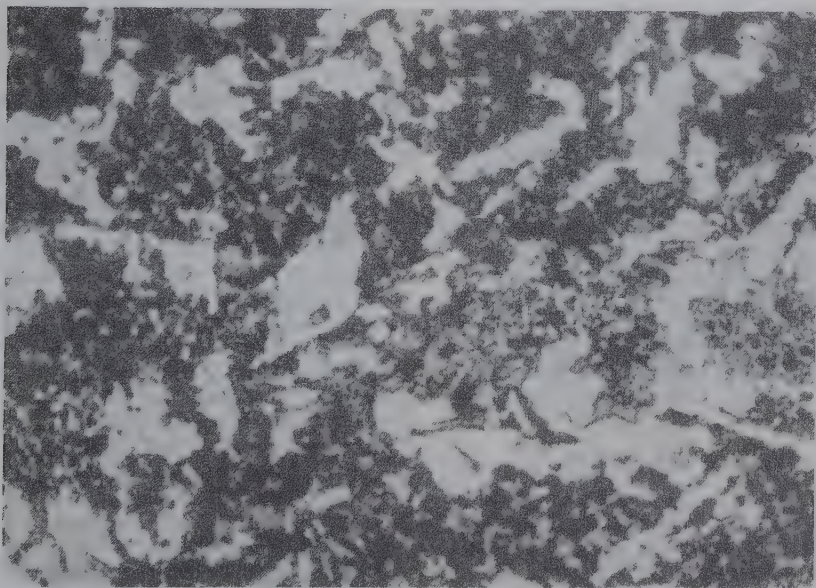


FIGURE 8. Metasomatic biotite-amphibole-nepheline-pyroxene rock with palimpsest texture (after a poikilophitic texture). Without analyzer. 20X.

cratic rocks with nepheline. Both processes have been observed many times in alkaline intrusions, but are more pronounced in the above-described transformation of nonalkaline basic rock (dolerite) into nepheline-rich alkaline rock which is no different in mineral content from the ijolite-melteigite intrusive rocks.

On the strength of these observations, of course, it cannot be said that there has been metasomatic formation of all or most of the al-

kaline rocks of this and allied massifs. Nevertheless, the observations show that there is a metasomatic path for the development of nepheline-rich alkaline rocks.

3. The curious rocks developed in the outer ring of one of the alkaline intrusions, combining a high carbonate content with a great amount of potassium feldspar or nepheline and alkaline pyroxene, are, mineralogically speaking, very close to certain silicon-rich carbonate rocks.

Since the most likely origin of the rocks described by the author is formation through calcium metasomatism of intrusive alkaline rocks (chiefly nepheline and alkaline syenites, our data can be considered a fairly convincing argument in favor of the hypothesis of metasomatic origin of at least some of the carbonatites of other regions.

4. Since there has been a great deal of evidence given in favor of the extensive development of metasomatism in the massifs investigated, it should be stressed that there can be no doubt that, first, these massifs are magmatic in origin (there were a number of intrusive phases) and, second, that the metasomatism accompanying the intrusions (autometasomatism in the broadest sense of the word) was superimposed on rocks which had crystallized from a magma. This is shown primarily by the frequently observed normal ratios between intrusive alkaline rocks with various compositions, and also by textures and structures which are typical of igneous rocks. It was precisely the nonconformity with these natural laws that made it possible to detect the different manifestations of metasomatism described.

This article was already submitted when there appeared in the Doklady of the Academy of Sciences of the U.S.S.R. (vol. 124, no. 2, 1959) an article entitled Age ratios of rocks of the alkaline ultrabasic complex of the North Siberian platform by G. G. Moor. It rightly points out that the relative age of the alkaline ultrabasic rocks of the North Siberian platform is of great petrologic interest. But the author has not given a sufficiently objective account of the history of research into this problem. It is not the work of G. G. Moor that has enabled the age interrelationship of alkaline and ultrabasic rocks of complex intrusions to be brought to light.

The first indications that the intrusive alkaline rocks were younger than the traps were given by Ye. L. Butakova in 1935 on the basis of data collected by V. Ye. Savitsky, when she recognized alkaline metasomatism (aegiritization) of dolerite at the contact with the Odikhinch intrusion. At the conference of the Scientific Research Institute of Geology of the Arctic, held in the spring of 1956, Ye. L. Butakova spoke about these observations in answer to G. G. Moor, who had expressed the opinion that the traps were younger than the complex alkaline ultrabasic intrusions. The truth of Butakova's point was later confirmed by V. F. Motychko.

In the summer of 1955, we observed the very interesting fact, described in this article, of the conversion of dolerite into nepheline-rich alkaline rock at the contact with another alkaline intrusion (Dalbykh). In 1957 these facts became known to Moor during a discussion. He did not mention, however, when describing identical phenomena that he was not the first to observe in basic rocks manifestations of metasomatism which determined the age relations between traps with alkaline ultrabasic intrusive rocks in the North Siberian platform.

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MANGANESE TOURMALINES¹

by

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• translated by Royer and Roger, Inc. •

ABSTRACT

The role of manganese in the chemical composition and coloring of tourmaline is discussed. It is shown that manganese tourmaline-tsilaisite is similar to tourmaline-elbaite in composition and condition formation. The miscibility in the sherlite-elbaite-tsilaisite system is complete, but in the sherlite-dravite-tsilaisite system there is a gap between the dravite and tsilaisite, similar to the relationship between dravite and elbaite.

Manganese may be present in tourmaline in the form of Mn^{2+} and Mn^{3+} . The pink coloring of the tourmaline is caused by Mn^{3+} . This conclusion has been drawn from data provided by many authors on the nature of pink coloring of tourmaline, the dyeing properties of Mn^{2+} and Mn^{3+} , the possibility of the existence of Mn^{3+} during the crystallization of pink tourmaline, and the distribution of manganese in differently colored tourmaline. --auth.

In tourmaline, manganese is the mineral-forming component, but tourmaline with a high manganese content is comparatively rare. Tourmaline of this kind was first described by R. Prendel (1892) for the Urulg deposit in the Baykal region (Borshchovochnyy Ridge). According to his data, pink tourmaline from this deposit contained 4.06 percent MnO .³ In 1910, Duparc, Wunder and Sabot, published the results of their chemical analyses of tourmaline from Tsilaizina in Madagascar. Straw-colored, black and brown tourmaline they discovered contained 5.14 percent, 5.69 percent and 5.85 percent MnO , respectively. Studying the isomorphic miscibility of tourmaline, Kunitz (1930) singled out the manganese component as the final member of the isomorphic series of tourmaline, and called it tsilaisite after the name of the deposit.

The presence of tourmaline with a high manganese content in the Borshchovochnyy Ridge deposits was later confirmed by V. Kunitz (1930), N. V. Levenfish (1938), and T. N. Agafonova (1947). V. Kunitz quoted the chemical composition (the analysis was unfortunately not complete) of dark yellow tourmaline with the highest manganese content as 8.21 percent MnO . Information on blue tourmaline rich in manganese from Southwest Africa has been published by Epprecht (1953).

This article considers the characteristics of tsilaisite, its miscibility with other members of the isomorphic tourmaline series, and the part played by manganese as a dye in these minerals.

COMPOSITION AND FORMULA OF TSILAISITE

Tourmaline with a high manganese content has a well-defined composition and is genetically associated with sodium-lithium pegmatites. To give an idea of the composition of manganese tourmaline, the appended table gives chemical analyses of some of these minerals as typical examples of various final members of the isomorphic tourmaline series.

Crystallochemical Formulas of Tourmaline

- (1) $(Na_{0.72}K_{0.02}Ca_{0.05})$
 $(Mg_{0.06}Li_{0.88}Mn_{0.07}Fe_{0.02}^{3+}Al_{4.52})$
 $[Al_{3.39}B_{2.86}Si_{5.75}(O_{27.40}OH_{2.18}F_{0.42})_{30}]$
- (2) $(Na_{0.36}K_{0.02}Ca_{0.15})$
 $(Mg_{0.05}Li_{0.12}Mn_{0.78}Fe_{0.08}^{3+}Al_{3.74})$
 $[Al_{3.63}B_{2.77}Si_{5.60}(O_{25.16}OH_{4.40}F_{0.44})_{30}]$
- (3) $(Na_{1.00}K_{0.08}Ca_{0.14})$
 $(Mg_{0.14}Li_{0.19}Fe_{0.05}^{2+}Mn_{0.60}Fe_{0.09}^{3+}Al_{3.60}Ti_{0.01})$
 $[Al_{3.61}B_{2.74}Si_{5.65}(O_{25.88}OH_{3.74}F_{0.38})_{30}]$
- (4) $(Na_{0.62}K_{0.02}Ca_{0.04})$
 $(Mg_{0.18}Fe_{0.29}^{2+}Mn_{0.03}Fe_{0.02}^{3+}Al_{3.27}Ti_{0.05})$
 $[Al_{3.33}B_{3.06}Si_{5.61}(O_{27.03}OH_{2.45}F_{0.52})_{30}]$
- (5) $(Na_{0.50}K_{0.04}Ca_{0.46})$
 $(Mg_{3.28}Fe_{0.08}^{2+}Fe_{0.02}^{3+}Al_{1.78}Ti_{0.14})$
 $[Al_{3.32}B_{2.87}Si_{5.81}(O_{26.00}OH_{4.00})_{30}]$

¹Translated from O margantsevykh turmalinakh; Mineralogichesky sbornik, Lvovskogo geologicheskogo obshchestva, no. 13, 1959, p. 139-148.

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³Green tourmaline from Sushitse (Moravia) containing 2.83 percent MnO was pointed out by R. Scharizer, (1889).

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Comparative Table of Composition of Tsilaisite, Elbaite, Sherlite and Dravite in Weight percent.

Components	Elbaite, pink, Baykal region ¹	Tsilaisite, brown, Tsilazina ²	Tsilaisite, green, Baykal ³	Sherlite, black, Central Urals ⁴	Dravite, brown, Gouverner ⁵
SiO ₂	37.34	35.79	35.61 ¹	33.78	37.39
TiO ₂	0.02	—	0.13	0.41	1.19
B ₂ O ₃	10.80	10.22	10.04	10.70	10.73
Al ₂ O ₃	43.70	40.06	38.64	33.80	27.79
Fe ₂ O ₃	0.08	0.61	0.79	0.20	0.10
FeO	0.04	—	0.33	15.11	0.64
MnO	0.54	5.85	4.52	0.25	—
MgO	0.26	0.19	0.61	0.74	14.09
CaO	0.29	0.90	0.85	0.21	2.78
Na ₂ O	2.41	1.22	3.30	1.92	1.72
K ₂ O	0.15	0.10	0.42	0.11	0.16
Li ₂ O	1.43	0.18	0.30	—	—
H ₂ O +	2.12	3.81	3.53	2.22	3.83
H ₂ O ⁻	—	—	—	0.19	—
F	0.88	0.90	0.76	0.98	—
Correction to F ₂ =0 [sic.]	100.06 — 0.37	99.83 — 0.37	99.83 — 0.30	100.62 — 0.41	100.42 —
Total	99.69	99.46	99.53	100.21	100.42

Notes: ¹ and ⁴ from Slivko, 1955; ² from Epprecht, 1953; ³ from Agafonova, 1947; ⁵ from Don-
ney and Burger, 1950.

Comparison of the composition of tsilaisite, elbaite, sherlite and dravite show that in general composition, tsilaisite is nearest to elbaite, occupying an intermediate position between elbaite and sherlite. This is shown by the intermediate content Al₂O₃, FeO + Fe₂O₃ and Li₂O in tsilaisite, compared with sherlite and elbaite.

This fact is clearly illustrated by the diagram (fig. 1), which gives the approximate mean content of the components (as well as for MnO) in different natural tourmaline with a composition nearest to the final members of the isomorphous series. The intermediate position of tsilaisite and elbaite and sherlite tallies completely with their place in the sequence of crystallization of the tourmaline, observed in sodium-lithium pegmatites. This is confirmed

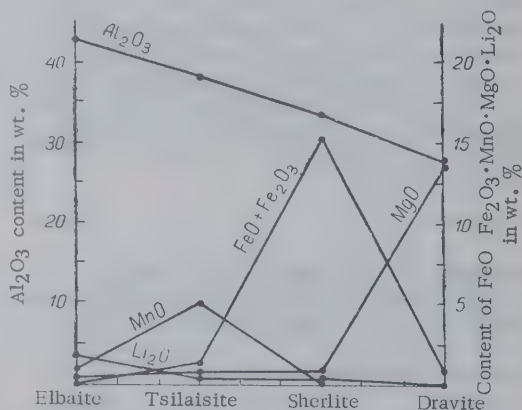
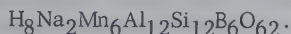


FIGURE 1. Content of most important oxides in tourmaline of different composition

by complete similarity between the given diagram (see fig. 1) (excluding dravite) and the diagrams which we made earlier on the change in the tourmaline composition from sherlite to elbaite, i.e., from the beginning to the end of tourmaline crystallization (Slivko, 1957).

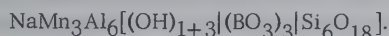
Kunitz (1930) singled out tsilaisite as an independent final member of the isomorphic tourmaline series and represented it in the following form by analogy with dravite and sherlite:



Epprecht (1953) gives a similar formula for tsilaisite:



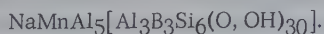
In his reference book, Strunz (1957) gives the formula of tsilaisite as follows:⁴



Although these formulas for tsilaisite are different at first sight, in actual fact they are the same. The same ratio of Mn to Al, 1:2, is maintained throughout. Here Strunz (1927) terms tsilaisite a hypothetical end member of the tourmalines.

Analyzing the crystallochemical formulas of tsilaisite specimens, including those given at the end of the table, we come to the conclusion that the ratio Mn:Al in natural high manganese tourmaline does not in actual fact exceed 1:8 (taking into account the aluminum in these hexad and quadrad coordinations). Hence the tsilaisite formula with the ratio Mn:Al=1:2 makes its composition truly hypothetical.

To our way of thinking, by using the general formula for tourmaline given by N. V. and Ye. N. Belov (1949) as the basis, we can derive the following formula for tsilaisite:



Thus, the formula, on account of its proximity to that of elbaite, is similar to the formula for the latter, especially since on the basis of the actual composition of elbaite, the ratio Li:Al in them is also equal to 1:8. Nevertheless, nobody is going to call elbaite a hypothetical end member of the isomorphic tourmaline series. The calculation of the tsilaisite formula, on the basis of the actual composition,

has made it possible to establish its place among other types of tourmalines and to study the possibility of isomorphic miscibility in tourmaline, including the tsilaisite component.

Figure 2 shows a miscibility diagram for the sherlite-elbaite-tsilaisite system, plotted on the basis of recalculation of 30 tourmaline analyses. As can be seen from the diagram,

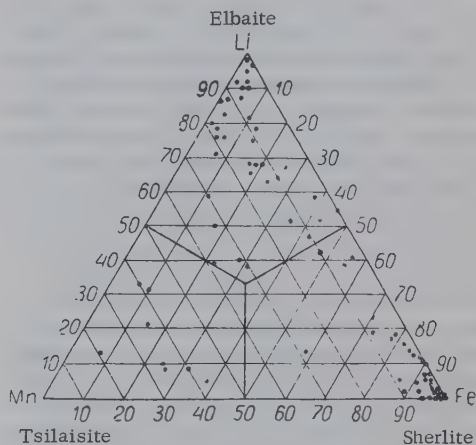


FIGURE 2. Diagram showing miscibility in the sherlite-elbaite-tsilaisite system

the system shows the complete miscibility of all three final members, although tourmaline with a high manganese content is comparatively rare. A particular mineral type of tourmaline, sherlite-elbaite-tsilaisite, can be singled out from the system under consideration in view of the complete miscibility.

Another diagram (fig. 3), which gives 116 tourmaline analyses, describes the miscibility in the dravite-sherlite-tsilaisite system. Here we can follow closely the complete and contin-

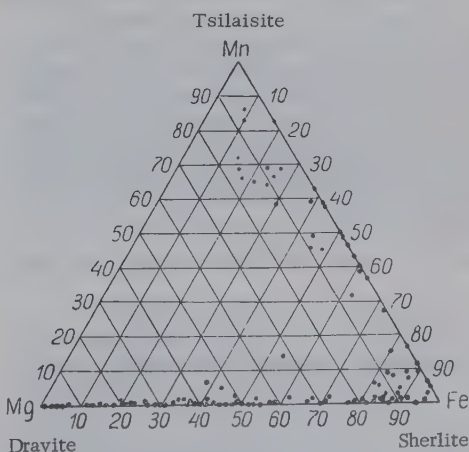


FIGURE 3. Diagram showing miscibility in the dravite-sherlite-tsilaisite system

Epprecht (1953) and Strunz (1927) took as their basis the tourmaline formula derived by Donney and Buerger (1950, 1951).

uous miscibility, on the one hand, of dravite and sherlite, and of sherlite and tsilaisite, on the other, while the dravite and tsilaisite do not mix to any extent at all (the dravite component content in tsilaisite does not exceed 20 molecular percent, but dravite contains only small quantities of manganese).

We observe an identical state of affairs in the dravite-sherlite-elbaite system in which the rift between dravite and elbaite is clearly marked. Some investigators, in particular Epprecht (1953), attempt to explain the nonmiscibility of dravite and elbaite on a purely crystallochemical basis. We feel that the lack of miscibility of dravite and elbaite is something of a geochemical nature due to the sharply differing conditions under which magnesium and lithium tourmalines form. It is clear that the same thing can be said of the nonmiscibility of dravite and tsilaisite, since high-manganese tourmaline forms in pegmatite of the sodium-lithium type (compare with elbaite), in which crystallization takes place at a low manganese concentration in the mineral-forming medium. At the same time dravite occurs under conditions of a low manganese concentration. There is no doubt that there can be no question here of the impossibility of the isomorphic replacement $\text{Li}^{1+} - \text{Mg}^{2+}$ or $\text{Mn}^{2+} - \text{Mg}^{2+}$, because compared with minerals more simple in structure, the bounds of isomorphic replacement in tourmaline are incomparably wider.

In conclusion we should point out that in conditions of formation and composition, tsilaisites occupy an intermediate position between elbaite and sherlite, and because of their miscibility with other members of the isomorphic tourmaline series are analogues of elbaite.

ROLE OF MANGANESE AS TOURMALINE DYE

The investigation of the nature of the coloring of minerals on the basis of their absorption spectra and comparison of the latter with the chemical composition of the minerals, as well as with the absorption spectra of artificial compounds and glasses⁵ has been started comparatively recently. Nevertheless, analysis of the part played by manganese as a tourmaline dye and as a dye in certain other minerals has something of a history.

The first known curves for the spectral ab-

sorption of tourmaline were obtained by Weigel, Habich and Ufer in 1928. The authors assumed from these curves that the pink coloring of tourmaline was due to the presence of manganese, but they did not determine the level of oxidation at which manganese produces this coloring.

In 1935, Kolbe also expressed the assumption, on the basis of absorption curves which he obtained for pink tourmaline, that the coloring was caused by septavalent manganese (the author compared the absorption curves of pink tourmaline and a potassium-permanganate solution).

S. V. Grum-Grzhimaylo (1945, 1948) made a more thorough investigation of the absorption spectra of pink tourmalines and came to the conclusion that the pink coloring was due to trivalent manganese. This opinion is shared by the author of the present article, after study of a large number of samples of pink tourmaline from deposits in the Central Urals and Borshchovchnyy Ridge (Slivko, 1955).

In 1953, J. and O. Bredley (1953), taking into account the similarity between absorption curves for manganese sulfate and pink tourmaline, as well as the stability of Mn^{3+} under laboratory conditions at a high acid concentration, expressed the hypotheses that the pink tourmaline is colored by Mn^{2+} . A. S. Korzhinsky (1958) studied the behavior of tourmaline when heated and also pointed out that bivalent manganese was the cause of the pink coloring in tourmaline. He arrived at this opinion, having taken into account the fact that the pink coloring becomes more intense as the temperature rises.

Thus, rejecting the hypothesis put forward by Kolbe that the pink coloring in tourmaline is caused by Mn^{7+} , which has not been established in natural conditions, the difference of opinion with regard to the origin of the pink coloring in tourmaline can be reduced to the question, in which state — bivalent or trivalent — does the manganese give rise to this coloring.⁶ Unfortunately, it has not been possible so far to establish this by a direct determination of MnO and Mn_2O_3 . Hence, indirect evidence has to be used in order to find an answer.

Let us first take a look at the dyeing properties of Mn^{2+} and Mn^{3+} . Study of the coloring of glass has shown that manganous oxide colors them a pale yellow, while the higher oxide colors them bright pink, that is to say, Mn^{3+} constitutes a stronger chromophore than Mn^{2+} .

⁵In our opinion, the comparison of absorption curves for solutions and crystalline bodies (minerals) in order to gain an idea of the chromophores coloring the latter is insufficiently valid, since the ion chromophores in solution have a completely different environment from the crystal lattice; this must obviously affect the nature of the curves.

⁶Agafonova (1947) has put forward the hypothesis of the energy-chromatic nature of the fading of the pink coloring of tourmaline when heated.

This tallies with the observations made by A. Ye. Fersman (1958) that the dyeing properties of ions increase with valency (due to an increase in polarization and asymmetry). Glasses colored by Mn^{3+} produce an absorption curve similar to those of pink tourmaline. Similar curves are found in the case of corundum colored with Mn^{3+} , lepidolite and pink spodumene.

S. V. Grum-Grzhimaylo (1948) notes the effect of iron on the dyeing properties of manganese in glasses. Thus, the presence of 2 to 3 percent iron causes manganic oxide in the glasses to become, for practical purposes, the colorless lower oxide.

In the laboratory, manganic oxide is only stable in a highly acid medium. On the basis of this, J. and O. Bradley (1953) consider that manganese is uncommon in natural conditions in the form of Mn^{3+} and cannot be a mineral dye, particularly in the case of tourmaline.

A. Ye. Fersman has stressed, however, that "with manganese, as with iron, in the more primary forms of magmatic crystallization we only have Fe^{2+} and Mn^{2+} , whereas at the final stages we have Fe^{3+} , Mn^{2+} within the pegmatitic melt..." (1958, page 425).

V. S. Sobolev (1949) writes that Mn^{3+} most probably occurs in silicates as a slight isomorphic admixture. According to our data, Mn^{3+} undoubtedly causes coloring in minerals of the epidote group - piedmontite and sursassite. The same thing can be said of vorobyorite, kunzite and lepidolite, in which Mn^{2+} ($R=0.70$ kX) isomorphically replaces Al^{3+} ($R=0.57$ kX). The difference in the ionic radii ($\frac{R_1 - R_2}{R_2} \cdot 100$) is about 23 percent here, whereas in the case of Al^{3+} and Mn^{2+} ($R=0.91$ kX) it is 60 percent, which makes isomorphism between Al^{3+} and Mn^{2+} impossible.

To obtain some idea of the reason for the pink coloring in tourmaline it is worthwhile to consider the distribution of manganese in differently colored tourmalines. There is a high manganese content in yellow, brown (and black, when the iron content is high) and green tourmaline; in pink tourmaline the amount of MnO is not usually more than 1 percent (excluding the above mentioned analyses made by Prendel). At the same time, there is a higher iron content in green, yellow and brown tourmaline than in pink. This distribution of manganese in differently colored tourmaline suggests that manganese enters differently colored tourmaline at different stages of oxidation. This is mentioned in the works of S. V. Grum-Grzhimaylo (1945, 1948), J. and O. Bradley (1953), and M. M. Slivko (1955).

It is interesting to note that J. and O. Bradley, while attempting to link the pink coloring in

tourmaline with Mn^{2+} , speak at the same time of the possibility of manganese entering the pink and green tourmaline at different levels of oxidation. According to the data obtained by these authors, the pink color appears when the manganese content is greater than 0.2 percent, and the green color only in cases where the iron content ($Fe^{2+} + Fe^{3+}$) reaches 1 percent or more.

This opinion gives grounds for drawing a parallel between the behavior of manganese and iron together in glasses and in tourmalines. When the iron content is considerable, manganese is apparently present in the tourmaline in a bivalent state. If the manganese content is very high (and considerably exceeds the iron content), it may produce a yellow and brown coloring in the tourmaline (possibly together with iron oxide), i. e., the same coloring that it gives to glasses.⁷

In green tourmaline, when the iron content is high, bivalent manganese has no effect on the coloring, which is then due to the lower iron oxide. In pink tourmaline, iron is present in only very slight quantities and it is the Mn^{3+} which plays the part of the dye.

A. I. Ginzburg (1954) points out that at the end of the process of crystallization in tourmaline there is partial oxidation of the lower manganese oxide transforming it into the higher oxide, and pink tourmalines are the last to be delineated among the other color differences in these minerals. It is interesting to note that in the pink tourmaline of the Borshchovochnyy Ridge (analyst I. D. Borneman-Starinkevich) all or nearly all of the iron is in the higher oxide form, which also shows an increase in the oxidizing potential of the medium towards the end of the period of crystallization of tourmaline (Slivko, 1955). The ratio $Fe_2O_3 : FeO$ in the tourmaline as a whole also increases in this direction.

As the temperature rises, the pink coloring fades. This has been demonstrated by observations of the thermal fading of pink tourmaline by means of a spectrophotometer (Grum-Grzhimaylo, 1948; Slivko, 1955; Vedeneyeva, 1937; Vedeneyeva and Grum-Grzhimaylo, 1948), and is also pointed out in a number of publications (Bradley and Bradley, 1953; Karnozhitsky, 1891; Simon, 1908), on the basis of visual observations.

The irreversible discoloration of the pink may begin at about 200°C., and the color dis-

⁷There are both light and dark brown tourmalines with a low manganese content, and the coloring is due to ferric iron.

appears completely usually at 500°C. The "intensification of the pink coloring" above 600°C., observed by Korzhinsky (1958), is the result of the oxidation of the iron and manganese in the tourmaline at low levels of oxidation on the surfaces of the powder particles. This can be observed more easily when fractured sheets of pink tourmaline are heated. Here the bulk of the sheet is still colorless even at a temperature above 600°C., while a brown coloring appears in the fractures, showing the commencement of the decomposition of the tourmaline structure on account of the transition to the higher levels of oxidation of that part of the manganese and iron contained in the form of Fe^{2+} , Mn^{2+} and, possibly, Mn^{3+} .

Thus, we have considered three principle facts which give an indication of the cause of the pink coloring of tourmaline:

- 1) the dyeing properties of Mn^{2+} and Mn^{3+} ;
- 2) the possibility of the presence of Mn^{3+} during crystallization of pink tourmaline;
- 3) the distribution of manganese in differently colored tourmalines.

The views set forth above are evidence in favor of trivalent manganese as the dye in pink tourmaline; however, this does not exclude the possible presence in the pink tourmaline of manganic oxide in addition to the lower oxide.

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SYNGENESIS AND EPIGENESIS IN PETROGRAPHY AND THE STUDY OF MINERAL DEPOSITS (PART 2 of 2)¹

by

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B. Intrusive rocks and ore deposits in them

a. The granite problem

As previously mentioned several times, the granite problem likewise consists mainly of a discussion of syngenetic or epigenetic rock formation. One school of thought considers that granitization occurs by introduction and/or loss of materials from sediments to the point where a granite-like rock is formed. The opposite school of thought supposes that granites mainly form from melts by simple solidification without any substantial diffusionistic changes, and mostly from juvenile materials.

The nuances and degrees lying between these two extreme theories usually center around varied degrees of remelting or palingenesis, and around different quantity relationships between juvenile and remolten material. If one tries to classify different granitization concepts in accord with strongly active archetypic patterns or images, one arrives at first glance, at a tripartite division:

1. The group of those that see granitization mainly as a diffusionistic, emanationistic trans-

formation of sediments in situ (e.g., Perrin and Roubault, 1939, Sullivan, 1948, Goodspeed, 1948 pro parte, and Read, 1948 pro parte).

2. The group of those that suppose a cyclic, periodic subsidence, remelting and rising of sedimentary groups, and therefore a cyclic, palingenetic magma formation ("rebirth") from sediments (e.g., Read, 1948, etc., Borchert and Tröger, 1950 pro parte, Raguin, 1949 and 1953, Mehnert, 1953, Backlund, 1941, Schneiderhöhn pro parte, 1951, 1952 and 1953, and others).

3. The group of those that suppose chiefly juvenile magma formation, and that regard assimilation and remelting only as marginal phenomena (e.g., P. Niggli, 1941 pro parte, Wilson, 1957, and many others).

The author has (1952a and 1957c) pointed out some concrete difficulties in the diffusionistic granitization theories. As well, he recently (1958g) briefly referred to the startling similarity of these diffusionistic-metasomatic granitization theories of the migmatists with the equally diffusionistic-metasomatic mineralization theories of many magmatists. Further, he has shown that the mechanism accepted by the two seemingly opposed schools actually is identical - in both cases "soaking" of rock complexes is supposed. According to granitization theories based on metasomatism these diffusing solutions or gases ("fluids") produce granitic or even spilitic rocks (see section 4), while according to the theory of "klemegmatic" mineralization a hidden magmatic source emanates these materials through circulating hydrothermal solutions, or through "Brown-diffusion" (J. S. Brown, 1948) of gases and vapors. In both cases, the "telemagmatic" solutions cross thousands of cubic kilometers in order to form metasomatic gran-

¹ Translated from Syngeneses und Epigenese in Petrographie und Lagerstättenkunde: Schweizer Mineralogische und Petrographische Mitteilungen, v. 39, p. 1-84, 1959. Part 1 of this work was published in IGR, v. 3, no. 2, p. 119.

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ites or deposits in essentially isolated "lithologically-preferred places". What the magmatists propose therefore in reference to granitization is proposed by some magmatists for the "disseminated ores" in sediments as well as in intrusives.

(This remarkable affinity between two otherwise opposite groups may be regarded as interference between two pairs of patterns of thought, which are epigenesis-syngeneses and allothigenesis-autigenesis on one side, and fire and water on the other. Probably some other patterns of concepts are also present, e.g., the pair - rebirth and single event. Archetypic models appear most often in pairs; they are based on a certain contrast-tension, such as mentioned by J. Jacobi (1953, page 194). If Wegmann (1958, page 554) and Davidson (1957, page 668) object a priori to a certain antiactualism so may perhaps this be interpreted as an affinity to the concept of cycles (the archetypic model of rebirth) and to epigenesis, while on the other hand the singularity of and the gradual progressive change of the continents, found in the theories of Russel (1958) and Wilson (1957) could be based on the conceptual pattern of syngeneses and singularity of events or continuity; but on this we will report in more detail later.)

In metamorphism for example, isochemical metablastesis, or pegmatite formation through internal lateral secretion is more closely related to syngeneses or "authigenesis", while allochemical reactions, e.g., wide-spread diffusions and injections, are more closely related to epigenesis or "allothigenesis". Actually, seen on a large scale, diffusions as well as intrusions are epigenetic. In contrast, crystallization in itself (in the case of a magma, thus the actual rock formation) is something simultaneous, synchronous, and therefore actually syngenetic, whereas metasomatic granitization requires allochemical, epigenetic migrations of material. Therefore, when determining the time relationships between geological bodies and processes, it is important to bear in mind which space and which space elements are being considered.

b. Ultrabasic Rocks and Deposits in Them

Within the group of ultrabasic rocks and deposits the chromite and also the pyrrhotite pentlandite deposits offer probably the clearest example for the discussion of epigenesis and syngeneses. Again some see in amoeba-type grain boundaries, to name only one geometric example, proofs for metasomatism (e.g., Gillson), whereby most suppose that the ore mineral moved in later, even when it displays negative, recessive geometric shape. Others (e.g., Cameron) see in the horizontal geometry and textural details a strong proof for syngeneses, thus formation in and with the main rocks.

When today, in reference to Turkish serpentine and peridotite masses, both submarine extrusive (Bailey and McCallien, 1953, Borchert, and others) and intrusive (Gysin, 1952 and 1945, and Hiessleitner, 1951) origin are postulated, this reflects actually again the same polarity between syngeneses and epigenesis. It is possible, as mentioned before, to add an infinite number of examples to the ones just named. But here the intention was to offer a basic discussion of two concepts which dominate the study of ore genesis more than we realize (see also Hess, 1955).

c. The "Disseminated Copper Deposits" or the "Porphyry Copper Deposits", "Porphyry Iron Deposits", "Porphyry Molybdenum Deposits", etc.

In the German language this group of deposits is usually designated by the expression *Impragnationslagerstätten* (impregnation deposits). This German expression probably points rather to the genetic sense of additional impregnations and thus of a later introduction. In order to hold oneself free, as much as possible, from preconceived genetic interpretations, the pure geometric English expression is here preferred.

Now we find here also that the genetic interpretation varies from an extreme epigenetic, even tele- or at least cryptomagmatic (Belt, 1958) to a syngenetic interpretation (Neuerburg, 1958 and Amstutz, 1958e). Observations in southern Peru "porphyry copper" (1954b) and observations in the deposits of Chuquicamata and Braden (El Teniente) in Chile, and of ores of the related deposits in the western states of the U. S. A. suggest that at least in part the possibility exists, that the copper-containing solutions were in the rocks as primary constituents and formed as late crystallizations, whereby the "hydrothermal" alterations possibly belong to a late autohydrothermal phase.

Here again we do not want to exaggerate but we like to especially point out that at the present many observations can be interpreted in various ways. We stressed before that borderlines between epigenetic and syngenetic occurrences in the case of intramagmatic deposits can only be drawn with great difficulty. Autohydrothermal solutions will often move within the rock and partially also in surrounding rocks, according to the mechanism described by Neuerburg, as could be observed for example in the Cuajone deposit of southern Peru in many details.

The same discussion over similar "disseminated deposits" of pyrite and of molybdenite in intrusive rocks has also taken place. A related example is the magnetite deposit of Granite Mountain in Utah (Mackin, 1952) and, although somewhat different, also the Climax deposit in Colorado. Here, according to new proposals,

the ore-precipitating solutions originated from the immediate surrounding rock, thus are actually late-magmatic-lateral secretory or autohydrothermal-lateral secretory. One might designate these deposits as prototypes of a syngenetic-intramagmatic ore. — A more extensive discussion at this point should consider also the tin deposits of Cornwall and Bolivia and certain other deposits, as here also "disseminations" occur, and here as well a more or less intramagmatic formation could be taken into consideration. (Ahlfeld (1958) recently gave an extensive outline of the tin and tungsten deposits.).

A type of deposit, or better, part of a deposit only rarely touched by the discussion on epigenesis and syngeneses is that of the oxidation zones, because they are usually accessible in all parts, and we therefore are often still able to determine the sources, gradients, and distances of the migrations, and in this way see what has migrated and what has not migrated. An excellent summary of knowledge on these portions of deposits is given by Smirnov (1954). The author has pointed out some practical-geological and metallurgical consequences of an exact knowledge of oxidation zones in a paper with H. Ward (1956d).

Yet these deposits also were not quite spared by the question of the foreign nature or the "autigenesis" of certain materials, namely, elements such as V, Mo, Cr, etc., which according to Siegl (1947), Hegemann (1949), Schroll (1949), Schneider (1953) and Taupitz (1954) and others, segregate from the surrounding rocks, while other authors suppose the same origin for these elements as for the main ores.

d. On the Origin of Hypogene Ore Solutions

In reference to the actual source of hypogene ore solutions two or three schools of thought have developed, which cannot be clearly associated with the syngenetic or epigenetic modes of thinking. The one extreme group, represented for example by Spurr (1923) and Brown (1948), derives the ore solutions or ore magmas as veins, intrusions or diffusions from a basaltic substratum. Locke and Billingsley derive ore solutions also from sources other than direct magmatic sources. They derive ore solutions from deep, remelted fracture zones and "ore-chimneys".

The other extreme is represented by those theories, which always and ubiquitously suppose a mother magma, and which let this ascend always and everywhere near the surface or to the surface. Into this class belong those theories which have raised one of Lindgren's possibilities of formation to the exclusive mode of formation of deposits, namely the epigenetic-hypogene possibility. This extreme attitude at times had very many followers. However,

today we can ascertain the opinion that through the one-sided exaggeration of the epigenetic theories of Lindgren and because of the neglect of his syngenetic theories relapse rather than progress occurred.

As Varček (1955) showed correctly, Emmons' theory of the ideal batholith with zoning which is supposed to always occur, has something metaphysically idealized about it, and it has not left enough free rein for factors such as assimilation, preintrusive segregation of the ore solutions or pure intramagmatic formations of deposits, which are important or can prevail. The reason for the one-sided interpretation of Lindgren's theories is an interesting historical phenomenon to which we will refer to again later.

The first group of theories — represented for example by Spurr, Holmes, Brown, Locke, Billingsley and others — exhibits many epigenetic features, because the ore solutions are always derived from far below and are always foreign material, even if they do not appear in sediments but in presently exposed intrusions.

A third group, to which perhaps Lindgren himself, P. Niggli, Schneiderhöhn, and Ramdohr belong is not dogmatically fixed to the idea of a single source of ore solutions. In reference to this, this school probably lies between the first and the second (and in this regard Brown is also to be included). This third group considers also in addition the possibility of syngenetic formations and distinguished itself in this sense very much from the two first-named groups. But rarely do there exist sharp borderlines between patterns of thought. The third group, for example, supposes partly syngenetic, comagmatic origin for deposits within magmatic rocks, as for example the copper deposits in the lavas of Michigan, while others prefer an epigenetic-hypogene or supergene mode of origin.

According to Sawarizki (1950 and 1954), Saukow (1950 and 1953), Varček (1955) and others, and according to personal communications, the development of the theories on ore deposits in Russia has taken a similar course as it did in Europe, perhaps with the exception that for sometime the assimilation as an ore-genesis factor was stressed more strongly than in any other place, e.g., by Abdullajev.

Again only short references in this section on the hypotheses of hypogene "ore sources" could be given to essential traits related to the concepts of epigenesis and syngeneses.

C. Extrusive Rocks and Ore Deposits in Them

a. The Propylitic Deposits

The propylitic deposits and rocks can be designated as extrusive equivalents of the "porphyry coppers". Therefore, again, a

classification into intramagmatic and extramagmatic transformations can be applied. Both possibilities have been proposed, i. e., some regard propylitic changes as a result of late to postvolcanic "greenifications" ("Vergrünungen"), e. g., in the environs of subvolcanic gold and copper deposits (excellently described examples in the Balkans), and others prefer epigenetic proposals, whereby the solutions which bring about the changes must be gotten somewhere "from unknown depth" (well-described, but probably incorrectly interpreted examples in California).

In an attempt at a new classification of the deposits of magmatic or general endogene origin (1958e) a gradual transition is proposed between propylitic rocks and deposits and their basic equivalent, which are the keratophyric and spilitic lavas. (This is supposed to include the differentiation of basic to acid magmas not as uncontested assumption, but as possibility).

b. Spilitic and Keratophyric Rocks and Mineral Deposits

The continuation of research begun in 1945 in the Glarner Freiberg on spilitic rocks and mineral deposits embraces at this time about 340 examples having a similar manner of origin. According to results up to the present time, spilitic rocks and mineral deposits must be regarded as primary hydromagmatic formations in the sense of Benson (1915), Wells (1922 and 1923), Lehmann (1949), and P. Niggli (1952). Physically and chemically they form the bridge between magmatic rocks and processes of high temperature, and those of normal or "sedimentary" temperature. The hypothesis that the interpretation of primary textures is correct leads to the observation of a decreasing amount of spilitic rocks and deposits since the early epochs of the earth's geological history which is in harmony with the idea that the degassing of the earth also decreases.

According to Cissarz (1956 and 1957) and others, many Mesozoic and Tertiary lavas are accompanied by syngenetic deposits. The proof for syngenes is relatively easy when it comes to young deposits. Should the continuation of our investigations of Paleozoic and Precambrian lavas further corroborate the tentative results thus far obtained, namely that one can here also conclude chiefly on syngenes, then here too may be an indication for the steadily decreasing production of volatile matter, and thus diminishing degassing since the Precambrian as older lavas show relatively more often spilitic portions and ore deposits. Though there is already plenty of evidence for it, this concept is still largely hypothetical. Among the evidences there is for example, the possibility herein of distinguishing between originally spilitic and originally normal basaltic components by the

same degree of metamorphism, e. g., in the Keweenaw lavas of Michigan, in the basic lavas and tuffs of the gold deposits of Canada, western Australia, Kilo Moto, Kolar, etc. Those portions of the lavas and tuffs where the metamorphism is so strong that it leads to a convergence, that is, it has obliterated the original textures, are not included here. But these cases are much less frequent than commonly assumed. As the author (1958e, page 3) has shown, most spilite outcrops have furthermore been sampled incorrectly which has led to the idea of a sodium abundance.

In order to make a tentative proposal the author has tried to divide spilitic mineral deposits, supposedly the most widespread group of syngenetic-extrusive deposits, into three groups:

1. Sulfospilitic mineral deposits: Iron and copper sulfide deposits, which occur in or near spilitic lavas and intrusions and which often lead to the formation of pillow lavas (see below). Examples: the sulfide deposits of the Norwegian coast and of Cyprus, in Syria and partially in the Balkans and in Turkey; a part of those pyrite deposits of the Urals which are associated with spilites (Grigoriev, 1948), and of Novaya Zemlya and of western Tasmania, further, individual sections of the copper deposits in the spilitic lavas of Lake Superior, U. S. A. and Canada.

Iron and copper sulfide deposits in sediments, which are associated with spilitic lavas (ore formation from hot springs of these lavas). Examples: Many, perhaps even the majority of the Kupferschiefer deposits, e. g., in the Non-such-shale of Lake Superior (e. g., the White Pine Mine), in Germany, etc.

Iron and copper sulfide deposits with gold or pyrite-gold deposits in basic lavas and tuffs. Examples: Canadian Shield, Kolar, Kilo Moto, Gold Coast, partially Mother Lode, California, etc.

2. Oxyspilitic deposits (enrichment of Fe and Ti oxide): Kiruna as an intrusive example; the deposits of Iron Mountain, Pea Ridge, etc., in Missouri and some identical deposits in the western States and in Chile have the same origin.

As extrusive examples the Lahn-Dill region, many iron manganese and manganese deposits in the Alps, in California and in the Olympic Mountains of the State of Washington (spilites of the coast range) and at other places where spilitic and keratophyric rocks occur.

Perhaps partly also a main part of the Precambrian iron ore deposits in sediments, e. g., on Lake Superior, in Russia (Krivoi Rog and others), in Brazil and Venezuela (Cerro Bolivar), in Labrador and at other places, where we

could be dealing with extruded or exhaled Kiruna magmas.

3. Spilitic deposits with native metals: The copper deposits in the spilitic lavas of Lake Superior and numerous other deposits of the same type (native copper and silver).

Also the gold-pyrite deposits in basic lavas and tuffs in the old shields, which were named in the group of sulfospilitic deposits, but also in less quantity in younger lavas, thus, e.g., in Tertiary lavas of Hungary and Romania (see section C. c.).

Possibly also the silver deposit at Cobalt, Ontario, or parts of it.

The spilitic ore deposits are of the greatest interest to the discussion of syngeneses and epigeneses as spilitic magmas are simply hydrothermal intramagmatic or – in other words – hydromagmatic components of common magmas, thus, those portions of common magmas in which the volatile components are enriched and have not disappeared. Therefore they form the intermediate stages, spatially and chronologically between basaltic to andesitic magmas which show an even distribution of volatile components (if this ideal condition occurs at all), and those magmas in which differentiation into a volatile and a non-volatile fraction has reached an end (also hardly ever realized as an ideal condition).

As the formation of ore deposits is commonly connected with the volatile portions of magmas, we can assume that a frequent association of mineral deposits with spilitic rocks can be expected, which is in fact confirmed.

An additional characteristic of spilitic magmas now is as pointed out previously, their property of also forming deposits with major elements such as Fe, Mn, Si, Ti, Ca and perhaps also Al, K, Na and Mg. This one can only account for with the assumption that parts of the magma existed and differentiated in the hydrothermal or "wet" or just hydromagmatic state. If no substantial differentiation happens a holomineralic spilite results. But if differentiations occur, the most manifold "oligo-" or almost monomineralic rocks and/or deposits form.

Almost all of the following special rocks occur in all spilitic provinces: albitites, carbonatites, chloritites, serpentinites, cherts (often with Radiolaria e.g., see Wenk, 1949), iron ores and manganese ores, and partly also alunite shales (actually K-Al- deposits, see Leutwein, 1951). Transitions to sedimentary formations, that is mixtures of tuffaceous and volcanic exhalative with supergene-sedimentary material are widespread.

Although the foundation of this somewhat broadened concept for the genesis of spilites relative to ore genesis had already been established by Benson (1915), there are even today still representatives of an exclusive seawater-spilite theory, according to which the albitic-chloritic mineral association is caused by deep-sea extrusion. These may of course occur as local convergences; but on the other hand, the comparison of the submarine spilites with the terrestrial and the intrusive occurrences of spilites (e.g., Kiruna, Iron Mountain, etc.), speaks distinctly for a hydromagmatic origin of the spilitic parageneses. In addition, none of the lava samples from ocean depths show any significant traces of halmyrolysis or even of spilitization.

Also now and then it is still attempted despite extensive evidence, particularly in reference to the regular association of monomineralic "facies" of spilitic rocks in spilitic-keratophyric areas and in reference to the distinctly primary differentiation- and crystallization geometry and the gradual syngenetic transitions to sediments, to bring in epigenetically "from unknown depths" hydrothermal albitizing, epidotizing, silicifying, chloritizing, prehniting, etc., solutions, which are supposed to produce epigenetically the same, which autohydrothermal-syngenetically is explained simpler and without any undemonstrable assumptions as the following: the appearance of a ore solution feeding intrusion "at unknown depth"; the assumption of an accumulation of hydrothermal solutions occurring in this unknown intrusions; the assumption of the diffusion of these solutions through cubic miles of completely unchanged rocks of most varied composition and porosity e.g., as below the Lake Superior lavas.

There are many geometric and geochemical criteria in nature for the following assumption which still has to be experimentally proven: that at increasing water content a silicate magma gradually grades into a hydrogel. The transitions of holomineralic, spilitic or keratophyric lavas to cherts, carbonatites, serpentinites, etc., make this assumption probable.

A remarkable phenomenon, which has rarely been explained, is the frequent association of "bimodal lava pairs" in spilite provinces (in part also in normal basaltic provinces). The example of the lavas in the eastern Swiss Verucano, where spilitic and keratophyric lavas are deposited alternately with quartz porphyries according to no apparent pattern – always with thinner or thicker sediment banks in between – repeats itself in many other spilite provinces in exactly the same way. Whether this "bimodal", "bipolar" behavior is due to a discontinuance of the differentiation of hydromagmas or to some other factor, has not been solved. Perhaps we could reason that there is magma addition from two sources (from the basaltic substratum and the above "swimming" base of the continent) along the same fracture system.

Closing this small illustration of the problem of epigenesis-syngeneses with the spilite problem, three observations shall be mentioned in short, which are typical for spilite provinces: 1) the deposits of the Kiruna type. 2) the pillow lavas, which often (but not always only) appear with spilites. 3) the gold deposits in basic lavas which here have been interpreted tentatively as syngenetic-hydromagmatic (section C. c.).

1) The Kiruna type of mineral deposits, which was extensively described and interpreted as spilitic-keratophytic by Geijer (1931, 1935 and 1950), is still today in part interpreted as hydrothermal-metasomatic, in disregard for the obvious agreement between geochemical and geometric criteria. Lately another interpretation has been given, namely a remelting of iron enriched sediments based on the idea of regeneration (Landergrén, 1948). This last idea is probably based upon an incorrect selection of analyses and on the misleading assumption that oxidation could not also occur in a melt. Ridge (1957) has given a short outline of the Missouri iron deposits of the Kiruna type. In reference to this type of deposit we thus see also the same polarity of interpretations as in all preceding paragraphs.

2) The literature covering the problem of the pillow lavas is an excellent example of how necessary it is that geological phenomena are seen in the coordinate system of space-time, physicochemical conditions and that it is attempted to see and distinguish the single parameters of the physicochemical process. This helps too to separate oneself from the confining conception of the limited geological locus and to recognize that under certain circumstances the same phenomena can appear under quite different geological (e.g., geochemical) conditions, but which are physically equivalent.

In the case of the theories of the formation of pillow lavas the discussion in part still centers around the geological place. One theory stands only for submarine, the other represents only extrusive, and a third theory also accepts terrestrial formation. In addition in some papers there are restrictions in reference to the composition of the matrix. The sulfide matrices are almost always designated as epigenetic-metasomatic products.

The explanations for the formation of pillow lavas, proposed up to 1914, were compiled by Lewis. Since that time many authors, among others especially Vuagnat have contributed to the understanding of the process with a variety of papers. It is attempted with a comparison which is still in process to offer detailed criteria for the here already briefly-sketched concept.

If one tries to subdivide the process of the pillow lava formation into separate physico-

chemical conditions, it seems that the following explanation does justice to all occurrences so far found or described in the literature: at the formation of pillow lavas neither the compositions, nor the place of formation in themselves are deciding, but those physicochemical conditions which makes possible the formation or co-existence of two substances with substantially different consistencies [viscosities]: one (e.g., because of stronger polymerization or dehydration) better coagulated, coherent viscous substance or liquid (with greater surface tension, e.g., oil droplets in water or in more mobile oils), and the other a slippery material (less viscous, but mobile, liquid, perhaps also expelled from the first substance) with a low surface-tension.

These conditions, in the event of the movement of magmas on the surface of the earth, on the bottom of the ocean or in fissure openings, or under slight sediment cover – all loci, where pillow lavas were found – seem to have arisen, particularly in three cases: 1) when the lavas are mixed with wet muddy sediments. Examples: all those pillow lavas, where the matrix material is made up of limestone or other sediments, e.g., at Cerro del Moro near Arica, Chile. 2) in the simultaneous movement of lavas with a blended sulfide fraction obviously particularly in the extrusive phase, but in part perhaps also in the form of sills under sediments. Moreover, in itself, one could think of the possibility that tongues of lava flowed into primarily exhalatively or else sedimentarily deposited sulfide pools, which would represent a transition to the preceding manner of formation. Examples: the pillow lavas of Cyprus (Hills, 1930 and others) and the pillow lavas in the pyrite deposits of the Norwegian spilites, as in other extrusive sulfide deposits in or near volcanic lavas.³ 3) in hydro-magmatic spilitic portions of basaltic lavas, where during the movement the volatile fraction acted as lubricant between the coagulating pillows of lava. This type of formation seems to be by far the most frequent one next to the first one, and it was best described petrographically, yet often it was still explained epigenetically; examples are abundant on the Canadian shield, in Kolar, in Kalgoorlie, etc. Group 3 is always, group 2 often, associated with spilitic rocks.

These three groups are proposed as a basis of classification, whereby yet a fourth group has to be added, namely that, where the above-named fluid matrix-phases only consist of a thin or scarcely-recognizable interstitial film between the pillows, because there never existed more

³ According to Geis (1958), the Norwegian pyrite deposits are, as mentioned before, to be regarded as syngenetic, as Vogt and Carstens already had stated in part and at certain times.

of this or because these fluid phases have disappeared. As will be shown in the forthcoming compilation of approximately 400 occurrences, there are transitions between all four basic types. Looking at this comparison it also seems that approximately 5 percent of all pillows already had formed or began to form before extrusion took place.

To come back to the discussion of syngenesis-epigenesis, it can be ascertained that here also an unprejudiced analysis arrives at more "natural", because less presuppositioned, results. If one leaves behind the epigenetic-metasomatic "connotation", which is being attached to the albitic-chloritic or sulfidic composition of the matrix by certain schools of thought, one can see that the syngenetic type of interpretation is much more probable, and that here again the epigenetic possibility has only marginal significance.

c. The Gold Deposits (Mostly Precambrian) in Basic Lavas, Tuffs and Closely Related Sediments

(Canadian Shield, Western Australia, Kilo Moto and Gold Coast, Kolar and probably also the Mother Lode, Tonopah, and other deposits.)

As previously shown (1957a, 1957e and 1958e), the author includes this group of deposits in the, for the most part, syngenetic-spilitic ores. Visits of mines and studies of polished specimens, thin sections and the literature revealed considerably more syngenetic than epigenetic criteria. As far as we know these criteria have never been pointed out and there has never been put forth a syngenetic interpretation. Among the most exact reports and descriptions, however, quite a number of authors had stressed the association with old basic greenstone or had expressly pointed out, that "strangely enough... the gold in these areas is not bound to the granitic batholiths, but to the pre-Silurian basic greenstones (diabases)" (Heim, 1934; see also Krenkel, 1957, pages 385, 388). Gill and other Canadians also don't seem to have any more faith in the old theory that the gold was brought up by granite batholiths. It seems that this concept has been upheld longest in western Australia. Duhoux (1950) and Sorotschinsky (1955) assumed epigenetic-emanationistic genesis for Kilo Moto. In support of their theory though, they need approximately ten more assumptions that a syngenetic explanation, which makes that kind of epigenesis highly improbable, and smacks of the metaphysical and alchemistic.

Rearrangements, to be sure, have happened as well, and they produce the features which lead to partly metasomatic or at least somehow epigenetic interpretations. A detailed analysis of fabrics and a separation into time classified periods in all probability will lead to the same results, as the author has obtained on the basis

of individual and comparative investigations of related deposits and rocks, although these investigations in many a way were still incomplete.

There was, to some extent, pre-training and perhaps, naturally, a certain prejudice based on the investigation of many spilitic samples, outcrops and papers. But no other differences could be determined than have to be expected occasionally and locally when metamorphism has occurred. With regard to all other properties the "albite and gold dykes and sills" and, naturally, the connected pillow lavas agree perfectly with the normal spilitites. Generally the same situation exists as in Outokumpu (in individual cases, as shall be stressed, in order to anticipate the accusation of too much generalization, migrations of materials extending over short distances have occurred): it is not to be perceived why the ore content should not have deposited syngenetically in the lavas, tuffs, and sediments. The regular association of the deposits with the greenstones is most easily interpreted as original, primary formations. Gold and/or silver and/or copper and/or lead and other deposits have been found in other places to be frequently and deeply associated with volcanic activity (Proctor, 1953, Buschendorf, 1950, and Cissarz, 1956, 1957, etc.)

Those roughly N-S trending zones in the Canadian Shield which are relatively densely covered with deposits, are perhaps pronounced fracture lines, but do not per se necessarily have to be epigenetic ore sources, but can in all probability be old fracture zones along which ore solutions were brought up syngenetically, and perhaps in part exhalative-volcanically in and with lavas, and then later possibly as well epigenetically. The fact that it is more natural to assume that the part of these solutions which rises to the surface is larger than the portion which disappears into the surrounding rocks, was explained elsewhere (1958c and 1958e).

With that, we have again arrived at the discussion of spilitic rock and ore formation, which was the subject of the preceding section except for the details just-mentioned.

D. Tectonic and Extra-Terrestrial Phenomena

Syngenetic and epigenetic, autigenetic and allothigenetic patterns of thought reach with their polarity also into the theories of extra-terrestrial and terrestrial phenomena such as earthquakes and weathering. The following example of an explanation of the causes of earthquakes is from Fuller's report of the big earthquake of New Madrid in the lower Mississippi Valley, U. S. A. (U. S. Geological Survey Bulletin, 1912, page 37): "The attraction exerted by the sun and moon on the earth's surface at times of new and full moon is decidedly greater than during the intermediate periods and has

been thought to be an appreciable factor in determining the times of earthquakes." In connection with this, Fuller cites examples with which he showed that no relationship exists between the change of the moon and the time distribution and the time of the quakes.

In a similar manner there is discussion over extra-terrestrial causes for weather changes, e.g., over Bowen's theory of rainfall distribution (see Weickmann and Smith, 1958).

Similarly the cyclic undulatory movements of the earth crust are regarded by one group of men as cosmic and by the other as terrestrial (see Baluchowsky, 1956).

Related to this duality of allothigenesis-autigenesis are partly also tectonic hypotheses. Wegener's idea of continental drift and its hypertrophy in the form of Rode's "playing card-origenesis" could be considered as an allothigenetic theory as compared to the autigenetic theory of Wilson and others.

An extremely strong polarity is encountered in the genetic interpretation of the moon's craters. The one school of thought in many books and papers represents an "insituistic" formation by late magmatic, polygonal tectonics (similar to the tectonics of the Precambrian of the earth) (Havemann, 1957, Sonder, 1956 and Wilkins, 1955). Through many criteria, the opposite school defends the meteor-crater idea, and it attempts to make credible this exogenesis through arguments that are partly incomplete or far-fetched (Baldwin, 1949).

In the above-mentioned examples we see different degrees of influence. While Fuller "vacua et libera mente" seems to keep merely to his logic criteria, one gets the impression, in the case of Rode, of a complete obsession by epi- or allothigenesis.

From other domains of life and not only from the sciences, we could cite examples which show similar "dipole-properties" that are related to syngeneses and epigenesis. Yet we have - with the exception of one example - to refer to another paper. This example deals with the discussion (which from time to time and in certain respects degenerated to a controversy that was carried on even in the churches, especially in the U. S. A.) of the idea of evolution, which through palaeontology also belongs within the field of geology. Here too, the question is rather one of mysterious acts of faith, when evolution is turned aside and an act of creation is supposed, which comes on us "from heights unknown to men". This assumption has much in common with the assumptions of an influence "from unknown depth", for instance with a mineralization if no channelways of supply exist. But as in the case of syngeneses, in both types of positive attitudes towards evolution there are

still certain assumptions present: in neo-Darwinism (Simpson) the idea of natural selection, and in orthogenesis (Schindewolf) the possibility of the formation of new types.

In the biological sciences, as has been true for some time in physics, it has become necessary not only to concentrate our attention on the borderline which "separates our individual conscious from the environment which surrounds us all, but at that other opposite borderline where this conscious borders the subconscious, the region of the objective-psyche, which as well surrounds us all" (Schmid, 1958, page 103). If we think of this "neglected dimension" of ours, the question may come up whether the certain excess of epigenesis which exists in many theories, according to the present work is not perhaps a matter of simple projections of an unadmitted knowledge about the unknown depths of our subconscious, thus a euphemistic tribute to the "unknown depths of our subconscious". But this question will be dealt with elsewhere.

Now, as we usually can learn about psychic problems and about the subconscious from exaggerations, from extreme cases and from dreams, so can we also learn much about the nature of scientific theories from extreme theories which approach a pathological nature or from fictions. ("Science fiction" in the U. S. A. has developed to a so-to-speak separate type of literature, and it offers good examples of archetypic fictions.) As examples, two extreme theories on the origin of petroleum are here mentioned.

In the second half of the last century Ludwig van Werwecke propounded that petroleum could be derived from magmatic sources (Papers of the Geological Landesanstalt of Elsass-Lothringen). And the Russian astronomer Velikovsky said not too long ago that the petroleum fell from heaven and so from extra-terrestrial sources got into the sediments. Again, we will leave open and keep reserved for later investigations whether and why extreme syngeneses are absent.

RESTATEMENT OF THE PROBLEM

As was stressed at the beginning, the aim of this work is not to establish a new dogma or perhaps to found a school of syngenetic thought. But it is attempted to free the problems from preconceived ideas, and it is also attempted if possible unprejudiced, "vacua et libera mente", to look for a new and possibly better answer. If in this process the usually dominant epigenetic line of thought for rocks and deposits was questioned more than the syngenetic line and, if the latter was often stressed and represented, it happened among other things as a counter weight for the hypertrophy of epigenesis.

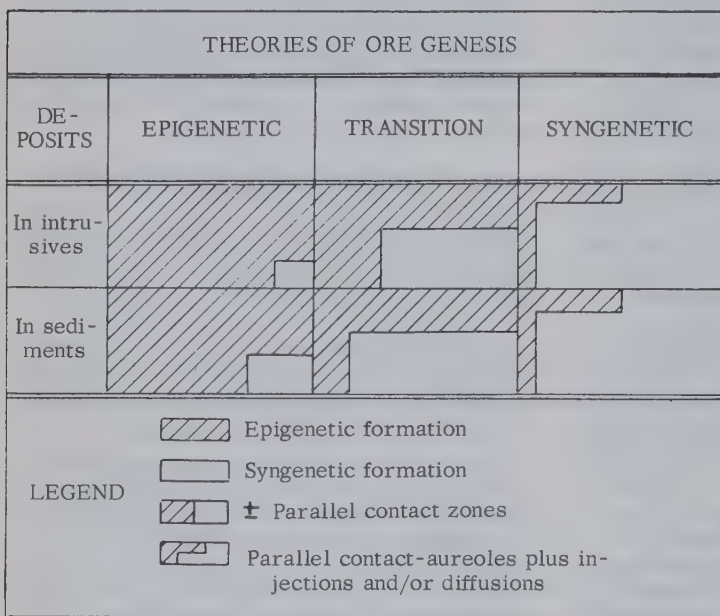
However the view expressed in this paper, that in regard to the science of ore deposits we

today are dealing with a hypertrophy of epigenesis again is only a view and is presented, within parentheses, in equation (2), together with the parameters time, space, physicochemical composition, and their derivations; this view therefore is also subjective. In order to decrease this subjectivity, the scope of the phenomena epigenesis-syngeneses was checked in three dimensions in regard to the historical dimension, in regard to the variability and type of appearance in the various branches of the geological sciences and in regard to aspects of depth-psychology though so far only tentative form. The result of this three fold aspect is the conviction that at this time, epigenesis is an incomparably stronger pattern of thought than syngeneses, and that for this reason the form of syn-

genesis which is shown here may perhaps be regarded as a better approximation of objective truth.

The form of syngeneses proposed here is regarded as moderate because it does by no means reject the contact effect and epigenetic migration of fluid phases, yet designates it quantitatively and by volume 10 to 20 times smaller than syngenetic processes of ore formation. With this it is not claimed that all deposits are syngenetic, but only denied that most of the ore deposits have to be explained a priori with extensive migrations and enormous metasomatic changes of matter.

This concept is presented at the right in the accompanying figure, while the extreme epigenetic-diffusionistic point of view is shown at the left.



In order to maintain, if possible, to our best knowledge and conscience, the "free sight", and to stay away from any dogma as far as possible, we took "a step back" and the research method itself was made the object of study. Should later on syngeneses become just as strongly a misleading pattern of thought, again an attempt would have to be made to free oneself from this by bringing this up to the conscious. Until that point, we will further work on the improvement of geochemical and geometric criteria for the better understanding of ore genesis, in order to make possible, at least in a purely logical way, a better demarcation of epi-

Granite and spilite genesis	Ore genesis
Syngenetic	
Juvenile and/or anatectic palingenetic granite magmas, or spilitic basaltic magmas rise and solidify <u>as such</u> or undergo at most autometamorphic transformations. Thus there is <u>no additional</u> later introduction of material, except in marginal contact zones.	If we disregard marginal phenomena (contacts), we are dealing almost always with syngenetic ore formations, i.e., co- and intramagmatic deposits form syngenetically in intrusives and in extrusives, and sedimentary deposits form in sediments.
Epigenetic	
Granites and spilites almost always form through metasomatic transformations (granitization and albitizations) of older rocks which are soaked epigenetically by emanations.	Ore solutions rise (almost exclusively) epigenetically-hydrothermally from magmas or epigenetically-regenerated from anatectic zones, into sediments, into comagmatic or other eruptive rocks and into metamorphic rocks (occasionally they are thereby linked with granitization and/or spiliteization).

genetic and syngenetic processes, and thereby to further eliminate the exchange of coordinates in the study of ore deposits.

In sum, an attempt will be made to characterize the main features of the preceding examples.

If one once more compares the genetic viewpoints of petrography with those of the study of ore deposits, the simple scheme results (presented below the figure, with which it should be compared).

As was mentioned above this arrangement or illustration brings to light, i.e., into our conscious, some rather surprising relationships. It becomes clear that certain, often antagonistic doctrines are actually closely related. Extreme magmatists explain many mineral deposits, e.g., the "disseminated copper deposits", the same way as many metasomatists explain the granites: through emanations from unknown depths, from where they emerge into the rocks through diffusion, and which in most cases are deposited metasomatically by replacing other materials.

It is in itself an immaterial nuance that certain "magmatists", e.g., in the case of the Mississippi Valley type, Bleiberg-Silesia type, Blind River-Witwatersrand type and other types of deposit, first bring up these ore solutions through veins, which, strange to say, were found in none of those areas, and then let them seep into the rocks through capillaries, while the "migmatists", though from the beginning, suppose diffusion migration. There are not a few also "magmatists" who, in the same way, suppose a diffusion migration of lead, zinc, etc., in the case of the Mississippi Valley deposits.

Therefore, it can be seen that the separation into a syngenetic and an epigenetic way of viewing things is much more far-reaching than the customary separation into magmatic and migmatitic viewpoints. Or, expressed in a somewhat different way, the so-called magmatic line of thinking is only slightly different from the migmatitic line of thought. The farther reaching scale is indeed probably that which measures the degree of the syngenetic or epigenetic thinking. In other words, of all possible patterns the polar pattern of syngeneses-epigenesis has the greatest influence on the geological sciences. The study of the literature shows that, of the four theoretical possibilities:

(rocks)	-	(ores)
syn	-	syn
syn	-	epi
epi	-	syn
epi	-	epi

all are represented, and one is at once surprised over the frequency of the "inconsequent" attitudes: "epi-syn" and "syn-epi", e.g., "epi"

in reference to deposits, "syn" in petrography. One reason for that may be the above-mentioned interference of patterns of thought or the adduced degree of specialization, or the lack of interest and of a possibility of looking around in the other branches of geology.

Since today the attention paid to syngenetic interpretations is once again increasing, as was just shown, and since the problem of syngeneses or epigenesis refers to more than just "the granite problem" or "the spilite problem", some distinguishing traits of the syngenetic concept shall be examined more closely.

This shall again not happen along the tendency to generalize and to exaggerate the syngenetic possibility of explanation. Here it is not maintained, to mention only one example, that all "porphyry copper deposits" or even all "vein deposits" are syngenetic, on the contrary, it is rather the case that the vein type commonly is epigenetic. Furthermore, it must be stressed that - even if perhaps certain relationships and certain patterns of thought which penetrate everything, have never before been displayed in the same way - the indication of the possibilities and probabilities of syngenetic interpretations, which is contained in this paper is in no way anything new, and that in fact, syngenetic lines of thought and modes of interpretation already in earlier times formed the nucleus of theories on ore genesis.

Actually with this a formerly used working hypothesis is to be reconsidered and thereby a "world of neglected dimension" (as Ostwald once called colloid chemistry), namely, the world of the syngenetic interpretation possibilities is to be discovered again and given more attention. As was shown in the examples many a time, we have to practice, among other things, more sedimentary petrography in order to be able to understand this world of the neglected dimensions. - Thus, in the following, additional traits of the syngenetic mode of interpretation will be given:

1) As was shown in given examples, in the case of syngenetic interpretations commonly only half as many steps are necessary for explanation than in the case of epigenetic explanations dealing with the same state. In the case of epigenesis, for example, the emanating material first has to gather within the earth, then a force and also channelways have to be assumed according to which these solutions can be mobilized and transported; further, the materials that are replaced must disappear from the rocks to make place for the neosom, and also for this removal channelways have to be assumed. A syngenetic explanation requires of all these steps and conditions only this one factor - that the material will be syngenetically enriched. That this is easier and in some respects more naturally possible in sedimentary environments

and magmas than in firm rock formations, is indeed obvious. The simplicity of the syngenetic interpretation is superior, and from a purely logical standpoint or methodically, has something convincing.

2) As briefly mentioned above it must also be pointed out, that already in the 17th, 18th, and 19th centuries, syngenetic ideas were discussed and advocated. Sandberger's lateral secretion idea presupposed syngenetic deposition. Lateral secretion only provides different degrees of enrichment.

3) The syngenetic spilite theory and the predominantly syngenetic exhalative interpretation of the main sulfide deposits in sediments and of many oxydic deposits leads to the possibility, that the formation of deposits could be an attendant phenomenon of the degassing of the earth, and that both, namely, the degassing and the formation of mineral deposits have decreased since the formation of the earth's crust.

4) The syngenetic-intramagmatic hypothesis permits visualization a simple connection between the "acidity" (the Si-content, the polymerization and viscosity) of magmas and the formation of deposits. In simplified terms, the following stands — the more acidic the magma, the less stable are the rock-forming minerals in the presence of ore solutions, the more autohydrothermal transformations occur near the end of the solidification process — and the more we commonly conclude on an epigenetic infiltration and transformation. Chromite and pyrite-pentlandite deposits very often are interpreted as intramagmatic, more or less syngenetic. Of spilitic deposits and rocks, only about half have been interpreted as syngenetic-hydromagmatic, while the propylitic deposits and the porphyry coppers were almost always explained as coming from subsequent, even if often autohydrothermal, migrations of material. In the compositional field of basaltic magmas, an autohydrothermal or, as we could say, a hydromagmatic crystallization is probably in most cases established beyond doubt. In contrast to this, in the domain of acidic magmas many questions are still left open, and the syngenetic-intramagmatic idea of the formation of the porphyry coppers as example is still strongly hypothetical.

The recently published attempt of a continuous classification of the magmatic ore deposits is based on the assumption that all magmas produce their normal share of ore fluids, thus all approximately the same amount, no matter what composition. The gap, supposed by many authors, in the dioritic-basaltic domain is therein overbridged. These brief remarks only refer to the physicochemical conditions. We cannot here go into the subject of geotectonic relationships.

At this point two confusions have still to be

anticipated. As was shown in Section 1, one has to be careful in distinguishing between the time of formation in reference to the surrounding rocks, thus between syngenetic and epigenetic or autigenetic and allothigenetic on one hand, and the origin of the ore substance or solution on the other hand, thus the concept-pair of supergene and hypogene.

Syngenetic hypotheses in no way are contrary to the importance of hydrothermal processes. This should also be clear from the fact that the idea of the gradually decreasing degassing of the earth's crust (Barth) was mentioned in the present paper. On the other hand, what is doubted is the assumption that the main portion of the hydrothermal gases and vapors and the materials which are dissolved in them is exclusively trapped and deposited within the earth's crust. Rather it is probable that a larger quantity reaches the earth's surface, and in the sedimentary troughs leads to hydrothermal, syngenetic deposits. Thus, in no way we doubt the existence and importance of hydrothermal ore solutions, but the emphasis of ore-genesis is simply moved from epigenetic-hydrothermal to syngenetic-hydrothermal. Yet again not all sulfide deposits should be interpreted as exhalative, but a large margin for the possibility of euxinic formations of purely supergene-syngenetic deposits should be allowed.

In many respects we should simply try "to get nearer to the truth by doubting all theories" and for this reason the question of genesis again and again was brought up anew. Among others we also have to clarify how correct the idea of the regeneration is. That now and then regeneration-like processes can occur, perhaps, for example the roasting-off of sulfur during the metamorphism of the Franklin Furnace deposit (Metsger et al., 1958 and Amstutz, 1957f) may indeed prove correct. Whether during these migrations metals also travel, probably has nowhere been established with certainty.

How much an exclusively epigenetic study of deposits runs into fundamental difficulties is also reflected in the variety and uncertainty of the concepts and methods of geochemical research on the alleged epigenetic-hydrothermal or epigenetic-regenerated ore solutions. One only has to think of papers by Graton, Brown and Morey. Today, increased attention is paid to the geochemistry of sedimentary processes, which no doubt is better than to further let the emanation of epigenetic-telemagmatic ore solutions in sediments take place over areas that often encompass several states. Out of the many works that offer a better understanding of sedimentary-geochemical questions, only a few are selected which may serve the student as a guide to literature: Fersman (1929 and 1935), Correns (1949 and others), Rankama-Sahama (1950), Krumbein-Garrels (1952), Keller (1954), Mason (1958), E. Niggli and P. Niggli (1948 and 1952), Leutwein

and Doerffel (1957) and Szadeczky-Kardoss (1957), whose extensive work has not yet been translated.

CONCLUDING REMARKS: RETROSPECTION AND PERSPECTIVES

If in the preceding pages now and then attempts for a better genetic answer, synthesis and interpretation were submitted, it always happened by the realization that we are still a long way away from a uniform concept of ore genesis. But we shall at least express the hope that by showing the red thread — epigenesis-syngensis — a short step was taken toward a more complete and integrated principle. Above all, we had the intention of formulating the questions afresh and more clearly, and to arrange them according to a more uniform viewpoint, in other words, to look for a working hypothesis which could get us out of the labyrinth of doctrines and which could get us a little further.

"The height of life" lies not there where everything has been clarified and the future is free of problems, but "there where no clarification or no certain decision has been reached", there, "where contrasts still have to be worked out, where — by clearly realizing as much as possible the value of that which was accomplished in the past — responsibility is assumed for that which is growing, that which is still uncertain". (Medicus, 1943, page 47).

As an answer to the question "what has to be done to get ahead?" the following five-point program is proposed, containing the points which have already been proposed here and just in the foregoing pages:

1) Above all we have to bear to stay in uncertainty in genetic interpretations, and we must not flee from this uncertainty by believing a given doctrine. Such an act of faith is always a short circuit and kills initiative for further research.

If we endure the uncertainty then, we dedicate ourselves more quietly to the first step of the investigation, namely, to the study of syngenetic and epigenetic criteria, and we do not look at the question of ore solution origin until later. If we already have committed an act of faith — perhaps not realizing it during our study or in reaction to a working hypothesis or even a dogma that was offered to us a little too beautifully or energetically — then we shall try to free our view of it and to detach the objects from those things which we up to now projected into them. Therefore we should free ourselves, if possible, from preconceived opinions, whereby during our studies it is usually true that the opinions, so to speak, have seized us, and not the other way around.

2) In the study of ore deposits more than be-

fore experimentation should be consulted, and attempts should be made in the laboratory to reproduce processes in nature, and to separate them into simple physicochemical systems. In this case we must not forget that experimental results again cannot replace our interpretation, but only permit supplementary observations based on simplifications. Many "experimental confirmations" are nothing else than a repeated onesided interpretation.

3) Furthermore, it seems to be important to draw no line between petrography, the study of mineral deposits, mineralogy and geochemistry, as was done and still is done at several instances under the pretext of restriction but to the disadvantage of all fields.

4) Then it should be advisable to concentrate more on the literature on the study of mineral deposits and petrography from the 17th, 18th and 19th centuries as this literature in many respects more freely and with less prejudice attacked problems and contains much excellent observational material (which often is freer from preconceived interpretations than papers of today).

5) Finally, it seems necessary to practice some philosophy and history of the sciences, and thereby "to take a step back" and to look at our methods of research as well as at our line of thinking. This though goes outside the limits of our profession, and we therefore have to cooperate with the historian, the philosopher and the psychologist.

"The natural sciences always reach superior objectives of knowledge only by an interest in its own nature" (Medicus, 1918 and 1943, page 27).

During a tentative attempt in the direction of this last point of program, it has already become clear that particularly in the case of rigid, dogmatic lines of thought in science the question is also one of archetypic domination, and of established attitudes and positions which can only be eliminated by bringing the subconscious contents out into the conscious.

This brings us a twofold gain: first, the fanatic investigator becomes a compatible scientist, because the liberation from domination by archetypic "patterns of thinking" means a step of individuation, and because thereby scientific theories are also free from stiffness, dogmatic blind alleys, and further steps are made possible for intuition and for logical thinking, which are not bound to be one-sided patterns.

Furthermore, through the bringing up into the conscious of inherent within ourselves living contents, a relaxation between "fighting" schools occurs, as we then see, that during the quarrel we both followed ancient patterns of thought

which live in the subconscious of both of us, and that therefore we actually were not "of different opinions", but were only under the influences of different inherent patterns. To speak with Frieda Fordham (1956, page 114) we too can say here: They "might also be more tolerant if they realized they were dealing with something inherent, when their partner's attitude differed from their own".

In other sciences, e.g., in physics and in biology, point five of the program has already largely become universal practice, while in geology this step still lies in the future.

Still the "insituists" and the "migrationists" fight without the appeasing and encouraging realization of inherent differences, and often one is really reminded of Goethe's account of the dispute between neptunists and plutonists, in which the two group names only have to be replaced by epigeneticists and syngeneticists: "As soon as in science one belongs to a certain restricted confession, every unbiased true concept is at once gone. The determined volcanist will always only look through the glasses of the volcanist, just as the neptunist and those who believe in the newest uplifting theory will look through theirs..." (page 555).

As the present work is only a tentative attempt to bring certain inherent connections into the conscious, very often it was not yet possible to relax and moderate the language sufficiently. The sense of a publication though is primarily also to bring a proposal into the discussion so that the mentioned ideas are able to ripen and grow through doubts and arguments because "the intellectual strength of a human being and also of a science is measured by the dosage of scepticism and doubt which he is able to digest, to assimilate. The resistant theory feeds from doubt..." (Ortega, 1958, page 61).

Furthermore, from the preceding geological exposé it can hardly be overstocked any longer that very important basic principles in our rock-formation theories, and thus centerpieces of geology, are passing through a distinct crisis. But this is assuredly a positive sign, because, as Ortega wrote "there is no better sign of maturity in a science than the crisis of its basic ideas" (1958, page 61).

According to P. Niggli science realizes "that for the most part it is antiquated imaginations which keep many from entering the sense and meaning of scientific aims" (1938, page 16).

It is probably quite certain that "antiquated concepts" have much more inertia and can even return from time to time, as our scientific theories are subject to still other influences other than only measurement, observation and logical deduction. Scientific theories cannot exist without symbolic images and imaginations.

"As regulating operators and builders in this world of symbolic images, the archetypes function precisely as the sought bridge between sense-perceptions and ideas, and are thus also a necessary prerequisite for the development of a scientific theory" (Pauli, 1952, pages 112-113).

Because of the recognition of these facts, the usual limits of geological thought were, for the purpose of the present paper, somewhat enlarged, because it seemed impossible to bring the already for many centuries known controversy between syngensis and epigenesis nearer to a better solution, with only a discussion on "the geology of the outside world". It was necessary to practice a little of "geology of the soul" and to try to reach an integrated point of view which led to the recognition, for the time being only in sketches, of some patterns of thought or archetypes which are especially active in geology.

In this way much had still to be left behind. For example, it still was not investigated whether Werner's neptunism was a rather extreme form of syngensis, or if the concept or symbol of water acted as an archetypic factor. Perhaps one can assume that plutonism and vulcanism archetypically were determined by the symbol fire. These two patterns near the second half of the last century were rather lax. It seemed that just at that time a new symbol took over some sort of lead, namely epigenesis or allothigenesis or the "migrationism", which in the last 40 years brought about extreme effects in the form extreme diffusion theories and other theories which postulated influences from "unknown depths or heights", thus from the interior of the earth and from extra-terrestrial regions. We would here, as was pointed out before, suggest tentatively that the serfdom for, or affinity to epigenesis, is the result of a general over-intellectualization. Epigenesis probably offers a certain substitute for religious metaphysical activity of the soul which, partly as a result of the rationalistic tradition, had become old-fashioned. Details of these relationships again have to be reserved for another paper. Here perhaps we may already mention the supposition that the locking-up and disregard of irrational domains of the human soul effected an eruption of the "lower" (as the author already interpreted 1952a the metasomatic granitization theories) into the domain of the intellectual. These eruptions, according to the thinking of geology, e.g., have been canalized into extreme epigenesis theories. We would not like this interpretation to be regarded as a reproach, because the author in the "peccavi" is completely included, but is now, due to the recognition of detailed relationships offered in this and other papers, completely convinced of the falseness and incompleteness of his concepts, and he believes himself "overwhelmed by the over-abundance of new perceptions".

Therefore it is proposed to try and see how

far we can get in theory and practice with the following working hypothesis: excluding contact zones and contact-near transitions with obvious or at least probable gradients (e.g., Granite Mountain near Cedar City, Utah, see Mackin, 1952), sedimentary origin is supposed for deposits in sediments, magmatic origin for deposits in intrusives (or perhaps occasionally also migmatic), and in the case of metamorphic deposits the origin of the enclosing metamorphic rock is assumed.

The reader has to decide if he wants to recognize the danger which in science, according to Niggli, is due to the word and the play-on words "because it struggles with self-created ideas", and if he wants to help to explore "again and again their sense and meaning, their role and history". It is left to the individual scientist whether or not he wants to recognize with Pauli that "archetypes are the regulating operators and constructive elements... which function as the sought bridge between the sense perceptions and the ideas". If he does, his effort and interest in the long run cannot remain concentrated on the geological objects alone, but will also have to be directed onto the idealogical on those patterns and their roots.

What is gained through this is an integration of the professional life, i.e., of the scientific activity into the cultural life, or, in other words, into life in its entirety. A higher degree or level of consciousness is gained which stipulates a philosophy of life. "Every realization of causes and intentions is a sprouting philosophy of life. And with the picture which the thinking man creases of the world, he also changes himself." (Jung, Psychological problems of the present time; 1950, page 268.)

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Preliminary note: An attempt was made, from the inherently nearly infinite number of papers which could be mentioned for every field, only to name those in the text, and to indicate those below which met the following prerequisites.

1) Papers which permit a thorough orientation on a deposit or on a range of problems and on the existing literature. This group may include approximately two-fifths of all works and includes, naturally, chiefly newer publications. Since extensive bibliographies covering the spilite and the granite problem are in preparation, these areas were almost entirely omitted.

2) Papers which have contributed important details to genetic research, but which often are not well enough known. Among these there are as well, therefore, a few older publications.

3) Fairly old papers which confirm Point 4 of the perspective, and which stem from past

centuries.

4) Perhaps yet a fourth group should be added, namely the papers of the author himself, which are cited nevertheless even though they do not belong in any of the previously-mentioned groups, since a paper such as the one under consideration somehow is at the same time a retro-spection and a prospection. Former interests and papers with no apparent connection suddenly appear to have a deeper common meaning. This has happened to the author on several occasions during the gradual composition and writing of this paper covering syngeneses and epigeneses, and therefore the papers concerned have been put together and have been quoted.

Completeness is not claimed, as the present paper represents a preliminary report, or a "progress report".

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Errata Notice

Vol. 3, No. 2, p. 119:

First item under

CONTENTS should read

Part 1 of 2 - not Part 2 of 2 M.R.

THE RIDDLE OF TEKTITES¹

by

G.G. Vorobev²

• translated by A.J. Shneiderov •

ABSTRACT

Since their discovery in Czechoslovakia in the 17th century, tektites have been found on all five populated continents. The largest Czech tektites weigh about 100 grams. More than 11 kilograms of samples have been collected from Australia alone. Three principal sources have been postulated: meteoric, lunar, and terrestrial. No theory has yet been generally accepted.-- M. Russell.

* * *

An interesting riddle of nature is the origin of tektites, glass-like bodies of an unusual form and composition found in Australia, Southeast Asia, Africa, Czechoslovakia, and the North and South Americas.

Many scientists of various countries are now trying to solve this scientific problem. However, some idle and misleading fictions appear from time to time in periodic press that have no relation to scientific investigation whatsoever. The purpose of the present paper is to throw light upon the present state of the problem of the origin of tektites, and to dispel the quandary caused by vulgar hypotheses.

Tektites were first discovered on Czech territory (Bohemia), in the basin of the Moldava (or Vltava) river; therefore, they are called there "Moldavites" or "Vltavias." Beginning in the 17th century, they have been found frequently among pebbles in river alluvium, and in the soil after its plowing, or after strong showers. They are sought after, cut into facets, and used as semiprecious stones under the name of Bohemian chrysolites. Several thousand specimens, weighing from a few grams to 100 grams were found on Czech territory over an area of 5,000 square kilometers. Another region where the Czechoslovak tektites are found is Moravia where specimens up to 235 grams were discovered.

Charles Darwin discovered similar bodies in Australia. The points plotted on the map (fig. 1) indicate the locations where those tektites (Australites) were found, giving an idea on the span of their distribution. More than 7,000 tektites were gathered from separate areas of the continent, totalling 8,000-9,000 square miles. A description of 11,946 specimens, 11 kilograms in all, was published by



FIGURE 1. The locations where tektites were found in Australia

Charles Fenner in 1934-1938. Most of them were found on the bare surface of the Australian desert, or in the young gravel-pebble deposits.

The neighboring tektite-bearing region in Indonesia was studied at the same time as in Australia. In 1879 Van Dyck, a Dutch scientist, reported that Chinese laborers of tin mines on the Billiton Island (between Borneo and Sumatra) had discovered some pieces of "obsidian", that were mistaken for black diamond. Similar bodies became later known on the Island of Borneo and Malacca Peninsula, and were named as Billitonites. In 1929 a report followed, telling of the tektites found on the territory of Indochina and South China (Indochinites) and six years later several thousands fragments of a large tektite (up to several kg in weight) were discovered in Lower Laos by a French mineralogist, Lacroix. According to data of several years' study, several types of tektites (Philippinites) were found in the Philippines. Near Manila City they all are deposited together in a small layer of gravel, covered, in places, by the later alluvial sediments. The largest specimen of the Philippinites weighs 226 g.

In 1927 it was believed that all tektites are distributed along a circle on the earth from

¹Translated from *Zagadka tektitov: Priroda*, Izdatelstvo Akademii Nauk SSSR, no. 6, p. 75-77, June 1960. Reviewed for technical content by Brian Mason.

southeast no northwest, as a result of the earth's passage through a large swam of stone meteorites. However, this orderly scheme was destroyed by finds in Africa (tektites of the Ivory Coast), in Peru, and Columbia (Americanites), and in Texas (Bediasites). Thus, tektites are found on the all five inhabited continents. They are so widely distributed at some places as to be considered a local curiosity. The tektites in southeast Asia and Australia have been known to the natives for a long time (thousands, or, at least, many hundred years). They are used as amulets, and have more or less stereotype names: "moon stones", "sun stones", star excrements", etc. It is considered possible that during such a long period the natives could have witnessed their fall as meteorites or other similar bodies.

Tektites are black and dark-green (very seldom colorless, pink, and violet-red), intense vitreous luster, conchoidal fracture, and so on. Tektites have the forms of spheres (often hollow), ellipsoids, fingers, drops, onion bulbs, pears, dumbbells, little boats, little bells, and their fragments (figs. 2 and 3).

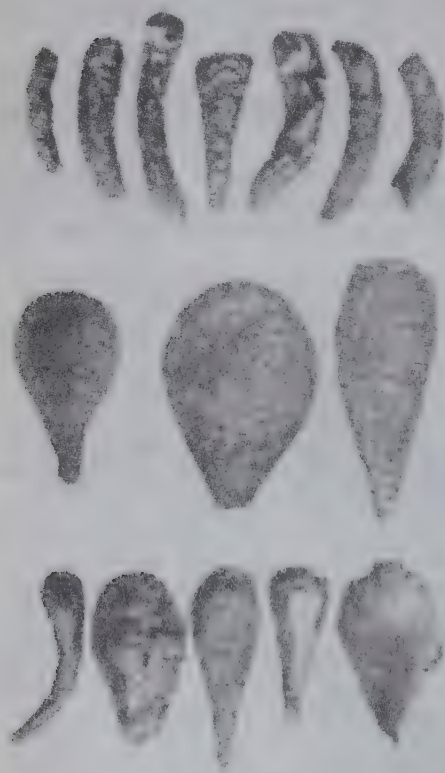


FIGURE 2. Tektites of various shapes

In their surface structure (the sculpture) they are reminiscent of meteorites, giving an impression of fluidity and spiral twisting. Fused quartz (lechatelierite) may be found in the surface layer. Tektites have a high viscosity, and high fusion temperature. Their chemical composition is mixed: along with "acid" the basic elements (such as nickel) are found. The tektites composition is distinctly different from that of volcanic rocks, and approximately that of certain sedimentary rocks.

Tektites are found either in the young (Late Tertiary and Quaternary), usually gravel-pebble, river alluvium, or in the soil on the surface of the earth. They are distributed in spreads formed at different times, sometimes superimposed one over the other.

The most enigmatic problem is the age of tektites. The age determined for individual territorial groups by the potassium-argon method gave, at first, age limits of from 200,000 years to 8.5 million years (let us remember that the earth's age is 4 to 5 billion years). Since, however the argon content in tektites is very low, one may assume its partial loss during the processes of re-fusion when the tektites were formed. Later determinations by the lead method gave quite a different age: 4-5 billion years. These data are in agreement with the isotopes Al^{26} and Be^{10} discovered in tektites in quantities exceptional for the earth's matter, but usual for meteorites and some other bodies of cosmic origin.

The numerous theories of tektite origin can be subdivided into meteoritic, lunar impact, and the terrestrial proper theories. The theories of artificial and volcanic origin were actively discussed at the end of the last century, but now have been completely abandoned. There are no volcanic rocks on the earth, corresponding in composition to tektites. Also, it is impossible to assume that all the ancient production of glass would use the same recipe for glass melting, and were so widely distributed on the earth.

A meteoritic theory was proposed by Franz Suess, a renowned naturalist, who was first to introduce the term "tektites" (from the Greek word for "fused"). In its present form this theory relates the tektites origin to an earth-like planet which existed between Mars and Jupiter, and was destroyed in a collision with another planet, or one of Jupiter's satellites 100 million years ago. The planetary fragments gave origin to meteorites, and the surface parts of silicic composition, after a prolonged period of superheating to 1,500-2,500°C, - to tektites. They were broken down in the earth's atmosphere, because of their fragility, and were widely scattered. In the case when the liquid tektite crust of the planet was in liquid

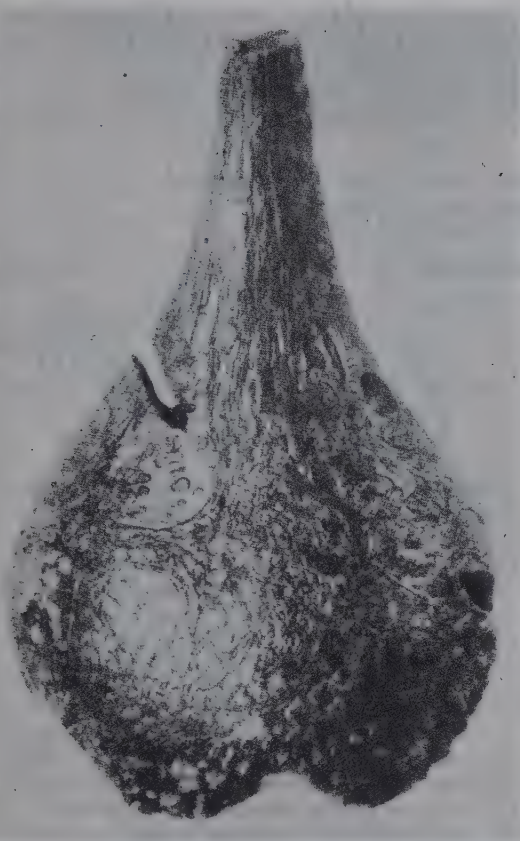


FIGURE 3. A characteristic appearance of a tektite (enlarged)

state, the scattering took place in the form of rotating clouds and drops, which cooled and solidified gradually into glass.

Theories which considered tektites to be the products of eruptions of lunar volcanoes, or fragments of the moon's surface, due to impacts of large meteorites, were developed parallel with the meteoritic theory. For the second case it was shown by S. M. Varsavsky mathematically, that lunar matter if thrown out under small angles ($15-20^\circ$) to the surface

on the moon (velocity 2.35 to 5.0 km per sec) insures a distribution over definite areas on the earth's surface. For example, a meteoritic fall at the point located at the middle of the eastern hemisphere of the moon, leads to a scattering ellipse on the earth in the region of the Australian continent.

Quite recently a communication was published by Kohman (*Priroda*, 1958, v. 182, no. 4630, pp. 252-253) on the discovery of tektites of radioactive isotopes Al^{26} and Be^{10} produced by cosmic irradiation in quantities exceptional on the earth's surface but quite common for meteorites. The presence of these isotopes, the investigator believes, shows that tektites are formed by a swarm of vitreous objects, which came to the solar system from outside, after spending at least one million years elsewhere in the universe.

The so-called earth shock (impact) theories ascribe the origin of tektites to a collision of a large meteorite, or the head of a comet, with the earth. The fused silicate rocks subject to the explosion wave gave to tektites their characteristic shapes and structure. These theories if accepted, permit the origin of several meteoritic craters (the impactites) to be related to the tektites.

The terrestrial theories proper are only slightly developed. They are usually arrived at by the exception method, when, by one or another reason, the cosmic theory of tektites is considered doubtful. I. Fridman emphasizes under the earth conditions that tektites can be formed only as a result of exceptional catastrophic processes.

The most probable, the present level of our knowledge, may be considered to be those theories which, directly or indirectly, relate the origin of tektites to some cosmic processes. No one of them, however, can claim a full acceptance since neither of them separately explains all the existing facts. It is quite possible that a development of an adroit and original "terrestrial" theory based on concrete geologic and geochemical evidence would change the balance of power between the theories of this problem.

Notes on international scientific meetings

THE GEOLOGICAL SOCIETY OF JAPAN, SELECTED PROCEEDINGS AND ABSTRACTS OF PAPERS READ BEFORE THE 66TH ANNUAL MEETING 7-9 APRIL, 1959¹

• translated by Kinkiti Musya •

In the list that follows, of papers presented in symposia and general meetings, asterisks designate those papers for which abstracts are herein presented. Abstracts from which to select were not available for all the papers given at the meeting. Selection was made on the basis of most probable general interest and significance to American geologists. --M. R.

SYMPOSIA

Granite and granitization

On granite

- *On the granites of Hokkaidō (by Yoshio SUZUKI)
- *Granites southeast of Kōfu City (Ushio FUJIMOTO and two others)
Petrologic study on the granite in the Misasa hot spring area (by Tokuzō SŌMA)
- *On the granites in Hiroshima and Shimane prefectures (by Hironao YOSHIDA)
- Granitic activity in the Chūgoku district and northern Kyūshū (Hidekata SHIBATA and Mitsuo SARUYAMA)
- Some peculiarities of the granite in the Outer Zone of southern Kyūshū (by Noboru ŌBA)
- *On the granites of Okino-shima Island in Kōchi Prefecture (by Kanei SUWA)
- *Summary of the chemical composition of granitic rocks in Japan (by Jin HATTORI and Tamotsu NOZAWA)

On granitization

- *On the granitization of the epidiorite and the gneissose granite in the valley of the Koshibu-gawa in the Ina district (by Motomu ISHII and Tetsuo YAMADA)
- *On the granite and metamorphic rocks in the area north of Niino, Shimo-inagun, Nagano Prefecture (by Yūtarō SAKAKIBARA)
- Granitization of slaty rocks caused by the Tenryū granite (by Iwai WATANABE and Moriakira KONOYA)

- *On the relation between the tectogenesis and the plutonic igneous activity in the Kasagi area, Kyōto Prefecture (by Ikuo HARA)
- *Gefüge analysis of the Ryōke lagengneiss and granodiorite in the Yanai district, Yamaguchi Prefecture (by Yoshihiko OKAMURA)
- *Granitization of the Ryōke zone in Mie Prefecture (by Hajime YOSHIZAWA)
- *On the iron and magnesium content of biotite in granite (by M. TATEKAWA)
- *The relation between the migmatite and the gneissose granite on the Pipairo River in the northern part of the Hidaka zone (Seiji HASHIMOTO and Toshiyuki KOSAKA)
- *Granitization of calcareous rocks and basic rocks in the Hida metamorphic zone (by Takeshi AOKI)
- *Differences and similarities between magmatic granite and granite formed by granitization (by Shinji SATO)
- *On biotite in granite (by Yasuo ŌKI)
- *On granitization and the distribution of radioactivity (by Susumu NISHIMURA and Jin'ichirō HATSUDA)
- *Granitization and zircon (by Yoshibumi KARAKIDA and Tōru TOMITA)
- *On the possibility of formation of granitic primordial magma (by Masao GORAI)

Bedded metallic ore deposits in Japan

Subject of discussion: How can we determine whether bedded metallic ore deposits are syngenetic or epigenetic?

Genesis and problems

- *Various views on the genesis of bedded sulfide deposits (by Manjirō WATANABE)

History of the research on various ore deposits

- Copper-bearing pyrite deposits (by Jun SUZUKI)
- *Manganese deposits (by Toyofumi YOSHIMURA)
- *Manganomagnetite deposits (by Akira TAKAHATA)
- *Water-stratified metallic ore deposits formed at the bottom of the Tertiary sea (by R. ŌHASHI)

¹Translated from Chishitsugaku Zasshi [Journal of the Geological Society of Japan], v.65, no.766, p.398, 401-404, 412-462, July 1959; translation prepared for the Office of the Engineer, Headquarters, U.S. Army Pacific, April 1960. Edited by Roy C. Kepferle, U.S. Geological Survey. Reviewed for technical content by Earl Ingerson. Published with permission of the Society and the U.S. Corps of Engineers.

INTERNATIONAL MEETING NOTES

Individual problems

Kieslager viewed from the development of of the Sambagawa crystalline schists (Summary) (by Jōji KOJIMA)

*Some notes on a Kieslager-like ore deposit in the non-metamorphic group of unknown age in the Kii Peninsula (by Isao SHIIDA and Kōshirō UMEDA)

The relation between ore deposits and igneous activity (Summary) (by Hideki IMAI)

Cupriferous iron sulfide deposits in the axial zone of Hokkaidō (by Toshiaki SAWA and Mitsuo FUNABASHI)

Kieslager in the drainage basin of the Tenryū River (1st report) (by Teiji KAMIYAMA)

*The relation between ore deposits and metamorphism (Summary) (by Hiroshi KANO)

Geology and ore deposits of the Sazare mine (Yōichi HIRATA)

On the ore deposits of the Sekizen mine, Ehime Prefecture (Hido TAKEDA)

On chlorite associated with some bedded cupriferous iron sulfide (by Kunihiro MUTA and Haruo SHIRAMIZU)

On the mode of occurrence and minor elements of magnetite and hematite from some Kieslager deposits (by Kazuo YAMAOKA and Yoshio UEDA)

*Distribution of the minor elements in sulfide minerals in some bedded, copper-bearing pyrite deposits (by Hideo MINATO)

Problem on the boundary between the Cretaceous and the Tertiary of Japan

On the difference between the Cretaceous and the Tertiary viewed from the heavy mineral constituents (by Azuma IJIMA)

*On the division between the Upper Cretaceous flora and the Eocene Flora in Japan (by Toshiji ŌYAMA)

*The boundary between the Cretaceous and the Tertiary viewed from smaller Foraminifera (by Yōkichi TAKAYANAGI)

*The boundary between the Cretaceous and the Tertiary in Hokkaidō (by Yasuo SASA and 20 others)

The Cretaceous system in the Kuji district (by Kiyoshi ASANO and Yasushi TERAOKA)

The boundary between the Cretaceous and the Tertiary in the Jōban coal field district (by R. SHŌJI and Motoki EGUCHI)

On the boundary between the Cretaceous and the Tertiary in Fukui and Ishikawa prefectures (by Zenzō TSUKANO)

*Biostratigraphic division (of the upper part of the Upper Cretaceous) based on fossil Pelecypoda (by Kōichirō ICHIKAWA and Yasuo MAEDA)

*The boundary between the Cretaceous and the Tertiary in Amakusa-shimo-jima (by Nobuhiro HATAE)

The boundary between the Cretaceous and the Tertiary in Amakusa-shimo-jima (by

Jōnosuke OHARA and 7 others)

*Problem on the boundary between the Cretaceous and the Tertiary viewed from international correlation (by Tatsurō MATSUMOTO)

*Summarized discussion

Applied geology, particularly geology of disaster

Applied geology

On the Arima hot spring, Hyōgo Prefecture (by Hisayoshi NAKAMURA)

Ground water in the central part of Nasunoga-hara [plain] (by Noboru SAGEHASHI and Kagetaka WATANABE)

On the subsidence of the ground in Niigata City (by Ryūji SUGIYAMA)

An experiment on the weathering of rocks (by Sekito HIRASHIMA)

*An example of the decrease of Young's modulus of a rock mass due to weathering (Tōru ONODERA and Shin'ichi KUDŌ)

On the collapse of the granitic zone with the Rokkō-san zone as an example (Ryūichi OKAMOTO and 2 others)

*Surface geology and soils (by Yoshio KATO and 2 others)

The relation between the landslide zones in Japan and geology

Recent trends in landslide research (by Hideo TAKAHASHI)

Landslides in the Kyūshū district (by Narito ŌHIRA)

Landslides in the Chūgoku and Shikoku districts (by Katsuji ŌNO and Hiroshi KUDŌ)

Landslides in the Mikabu zone along National Highway No. 13 (Matsuyama - Kōchi) (by Masao IWASAKI and 2 others)

Landslides in the Kinki district (Yasushi NISHIKAWA and Kyōichi TANAKA)

On landslides in Higadani, Miyatsu City, (Yosa-gun, Kyoto Pref.) (by Masatsugu MURAKAMI)

Landcreep in the Hokuetsu district (by Gonshirō KURIHARA)

Landcreep in the Tōkai district (Hisao YAMASAKI and Yoshio YAMADA)

Landslides in the Tōhoku and Hokkaidō districts (by Yoshimasa ISOZAKI and 3 others)

Landslides in the hot spring areas in Japan (by Takeshi ANDŌ and 2 others)

Landslides from the viewpoint of railways (by Masazō MIYAZAKI and G. YAMADA)

A study on the distribution of collapse localities in Japan from the viewpoint of geological structure (Preliminary report) (Tōru ONODERA and 2 others)

Problems on the Quaternary in Japan

The Quaternary of the northern Fossa Magna - Particularly the stratigraphy and geological structure of the Toyono complex (by Y. NISHINA and 9 others)

- On the peculiarities of the Quaternary crustal movement in the Hokuetsu district (by Yoshio KASENO)
- Pollen analysis of the *Menyanthes* bed (by Osamu YAMAGATA)
- The stratigraphy of the Narita group and associated problems (by Yō NARUSE)
- Stratigraphy of the Narita group (by Hisao NAKAGAWA)
- Characteristic deposition of the Narita bed around Imba-numa and its geologic significance (by Nobuo KOJIMA)
- *Collecting embayment-type fossil shells in the Quaternary beds of the southern Kantō (by Tōru MAKINO)
- *Changes of water temperature indicated by fossil Mollusca from the strata near the boundary between the Pliocene and the Pleistocene in the Bōsō Peninsula (by Sunao OGOSE)
- On the boundary between the Tertiary and the Quaternary viewed from organic carbon age determination (by Kazuo WATANABE)
- *On the paleo-climate in the old stone age in Kōzuke Province (by Fusao ARAI and 2 others)
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- Discussion of the problems of the Quaternary in Japan

Individual papers

Tertiary

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- Geology of the drainage area of the Shumarunai River, Uryū-gun, Hokkaidō (by Saburō SUGANO and 9 others)
- *Geology and oil-bearing structure in the area south of Aomori City (by Iwao KATO and 2 others)
- Sedimentation mechanism of the Neogene system in the northeastern part of the Shimokita Peninsula (by Isao IMAI and Konroku TSUSHIMA)
- On the green tuff (by Yōshin SUZUKI and 2 others)
- Geology of the western margin of the Takanosu basin and the area near the Daira mine, Akita Prefecture (by Hiroshi SUMI and Jirō HIRAYAMA)
- Geology of the eastern margin of the Takanosu basin, Akita Prefecture (by Hiroshi SUMI and Jirō HIRAYAMA)
- On the geologic conditions of vein-type ore deposition in the area from the middle part part of Akita Prefecture, to the western part of Iwate Prefecture (by Atsushi ŌSAWA and Shōji SAITO)
- Stratigraphy of the green tuff bed in the Oga Peninsula and igneous activity (by Kazuo

MIYACHI)

- On the distribution of the nonmarine beds considered to be the late Miocene developed in the eastern margins of the Yonezawa, Yamagata, and Shinjō basins (by Nobuya MINAGAWA)
- New contributions on the lower Neogene beds in the Dewa Hills, particularly on the "Takasegawa bed", "Kanayama bed", and the "Nozoki" beds (by Kazuo TAGUCHI)
- Problems on the Miocene and Pliocene in the vicinity of Sendai (by Naoaki AOKI and 2 others)
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- The structural geologic history of the hinterland of the Fujigawa Tertiary (by Tokihiko MATSUDA)
- Studies and micropaleontology of the Mikasa sedimentary basin, Shizuoka Prefecture (by Hiroshi UJIIE and Yōko INOUE)
- On the problem of the relation between the so-called Tamari beds and the Kakegawa group (by Ryūichi TSUCHI and Takao SUZUKI)
- On the mode of deposition of the lower Pliocene in the eastern margin of the Nōbi plain -- sedimentation facies and the development of the structural basin (by Tōru KUWABARA and Isao MATSUZAWA)
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- Paleo-ecological studies on the Kurosedani fauna (by Karyū TSUDA)
- Some problems on the Kurosedani complex (by Shōji FUJII and Shigeru KIKUGAWA)
- The Tertiary system in the Uozu district, Toyama Prefecture (by Yasuo SUMI)
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- Stratigraphy and structure of the Paleogene and Neogene systems in the Yuya-wan district, Yamaguchi Prefecture (by Sotoji IMAMURA and Kazuo OKAMOTO)
- * Microbiostratigraphic correlation of principal Neogene localities in western Honshū (by Yoshirō TAI)
- The Neogene system in the vicinity of Takahama, Matsuyama City (by Kōzō NAGI)
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Topographic development of the drainage basin of the Katsura River - Particularly on the terraces and the Quaternary in the vicinity of Uenohara-machi (by Kōshi SUZUKI and 3 others)

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On the marine Pleistocene series in the area west of Ise Bay (by Yoshio ARAKI)

SELECTED ABSTRACTS: SYMPOSIA

Granite and Granitization

On Granite

ON THE GRANITES OF HOKKAIDŌ. SUZUKI, Yoshio. This is a comparative study of the mineral constitution of the granites and contaminated rocks distributed in various places of Hokkaidō. On the other hand, the mineral constitution of all plutonic rocks was studied on the basis of recently-developed steam pressure fusion experiment. According to the results, it is considered that the side near Pl in a Modal Plutonic Field (SUZUKI, 1955) in a Q+KF, Pl, Mf diagram shows that steam pressure is high or the value of Q/Q+KF is high. Plutonic rocks are considered to approach to the composition of granite, their constituents changing by the conditions such as steam pressure, temperature, etc., in the course of formation. With respect to the contaminated rocks in the Hidaka mountainland, their tendency of constituent changes is at right angles to the tendency of plutonic rocks. These contaminated rocks change in the direction approaching the modal plutonic field and after

their entry to the field they probably change, in conformity with the general tendency. The difference of the mode of occurrence of plutonic rocks and the contaminated rocks is due to the difference of the ratio of Q and KF.

In addition, a comparative study of various plutonic rock masses in Hokkaidō and the Kitakami mountainland was made.

GRANITES SOUTHEAST OF KŌFU CITY (Particularly on the origin of the granite of the Tanzawa type). Ushio FUJIMOTO, Hidekata SHIBATA and Yasue OKI. The writers confirmed that, of the granites around the Kōfu basin, the one which formerly was regarded to correspond to the Tertiary granite of the Tanzawa type is granite of the Late Cretaceous Tokuwa type. The granite which corresponds to the granite of the Tanzawa type is distributed mainly in the south side of a line connecting Fujinoki with Onodera, and this granite distinctly traverses the granite of the Tokuwa type. Chemical analysis of these rocks was made and also the origin of the granite of the Tanzawa type was inferred. The granite of the Tanzawa type was formed by refusion or partial refusion of a mixture of spilite (keratophyre) in the green tuff area, sedimentary rocks interbedded in it, or its basal rocks (chemical analyses of 3 samples of spilite from the Misaka beds were also published). It was disclosed that Neogene plutonic rocks form two petrographic regions, the green tuff area and the non-green tuff area.

[Discussion] Hiroshi KANO: Your view on refusion is reasonable. But it is questionable whether or not the shallow intrusive rock in Ashikawa and the deep intrusive rock in Tanzawa can be treated in the same way.

OKI: Mr. Kano says that steam pressure is high and $\text{Na}_2\text{O}/\text{K}_2\text{O}$ becomes large. The ratio is too large and it cannot be explained by steam pressure alone.

ON THE GRANITES IN HIROSHIMA AND SHIMANE PREFECTURES. Hironao YOSHIDA. Granite or granodioritic plutonic rocks are extensively distributed in the San'yō and San'in districts, and small granitic intrusive rock masses accompanied by volcanics and diorite are found sporadically in the interior of the Chūgoku mountainland between the two districts. These plutonic rocks are divided into the Hiroshima granite complex, the central plutonic rock group, and the Imbi granite complex, based on the extent of distribution. The activity of the central plutonic rock group ranges from the Miyako epoch to the final stage of the Cretaceous and intrusion occurred three times. The intrusion of the Hiroshima granite complex is considered to have occurred in the beginning of the Tertiary, since in the final stage of the Cretaceous, vol-

canics intruded were of this complex. The Imbi granite complex was active in an earlier period than the Hiroshima granite complex, but there is no remarkable time gap between them.

ON THE GRANITES IN OKINO-SHIMA, KŌCHI PREFECTURE. Kanei SUWA. The granites are roughly divided into two types. One is cordierite hypersthene biotite granodiorite porphyry (Type I) and occupies the southeastern part. The other is tourmaline biotite granite (Type II) and occupies the northwestern part. Type I has been traversed by Type II, and pegmatite is found intruded parallel to the joints of both granite masses. These rock masses have raised the alternation of sandstone and shale (Shimanto group) and intrude the alternation, but have not exerted thermal metamorphism.

The granites closely resemble the Kumano acidic rock in respect to chemical composition. The composition of the plagioclase hypersthene silixite in Kumano closely resembles the intermediate or noritic charnockite. Type I was produced by refusion of this charnockite. That is, the cordierite and hypersthene are not xenocrysts. Very few xenocrysts of sillimanite and spinel are contained in Type I. A possible explanation of the formation of Type I is suggested by Schairer's experimental study (1954) and the existence of cordierite-bearing charnockite. The existence of Type I shows the existence of relatively high temperature charnockitic magma at least locally and this can be formed as a hypabyssal rock. The residue is considered to have formed Type II. Moreover, the geochemical behavior of Pb and B is mentioned.

SUMMARY OF THE CHEMICAL COMPOSITION OF GRANITIC ROCKS IN JAPAN. Jin HATTORI and Tamotsu NOZAWA. This is a summary of the values of chemical analyses of 471 granitic rocks published in various publications up to 1956. Granitic rocks have a chemical abundance of more than 55 percent SiO_2 , and quartz porphyry is included to some extent. Excluding imperfect analyses, analyses made before 1900, and those of which figures are mistaken from the 471 analyses, the average values were calculated on the basis of 390 analyses. The average values are as follows: SiO_2 69.98, TiO_2 0.41, Al_2O_3 15.09, Fe_2O_3 1.09, FeO 2.59, MnO 0.11, MgO 1.23, CaO 3.25, Na_2O 3.45, K_2O 2.93, P_2O_5 0.13, $\text{H}_2\text{O}(+)$ 0.75 (sic), and $\text{H}_2\text{O}(-)$ 0.29. Taking 131 analyses of granitic rocks in Finland from the data by L. LOKKA (1950), the average values were calculated. The average values are SiO_2 67.17, TiO_2 0.54, Al_2O_3 15.28, Fe_2O_3 1.12, FeO 3.00, MnO 0.07, MgO 1.25, CaO 3.18, Na_2O 3.78, K_2O 3.48, P_2O_5 0.19, $\text{H}_2\text{O}(+)$ 0.75, and $\text{H}_2\text{O}(-)$ 0.15. Comparatively speaking, granitic rocks in Japan abundant in CaO , are poor in total alkali and high in $\text{Na}_2\text{O}/\text{K}_2\text{O}$.

ON THE GRANITIZATION OF EPIDIABASE AND GNEISSOSE GRANITE IN THE DRAINAGE BASIN OF THE KOSHIBU-GAWA, INA DISTRICT, NAGANO PREFECTURE. Motomu ISHII and Tetsuo YAMADA. The gneissose granite in the drainage basin of the Koshibu-gawa is characterized by remarkable changes of lithofacies and texture of metamorphic rock. This granite is intercalated by hornblende-biotite gneiss considered relict, and xenoliths of epidiorite and Ryōke metamorphic rock are abundant. Thus local granitization is found in various places. One example of granitization of epidiorite revealed the changes in chemical composition and, in addition, the relation between the granitizations of epidiorite and the chemical composition of gneissose granite was considered. In the granitization series of epidiorite, Al_2O_3 decreases while Na_2O increases ($\text{Na}_2\text{O} > \text{K}_2\text{O}$). The lithology and chemical composition of the granodiorite that is a final product of the granitization series and the granodiorite in gneissose granite closely resemble each other. The gneissose granite and rocks of the granitization of epidiorite are richer in Al_2O_3 and Na_2O than the granites of the Ryōke zone in Central Japan and they have fairly peculiar petrologic character.

underwent tectogenesis prior to the Ryōke metamorphism. This tectogenesis is considered to have occurred through the present Ryōke zone and the intermediate non-metamorphic zone of KOJIMA (1953) in the Sangun orogenic phase. This tectogenesis was named the Tamba transformation. This transformation zone is almost completely unaccompanied by recrystallization of rocks. The Ryōke metamorphic action occurred overlapping the Tamba transformation action with a time gap. In the older Ryōke metamorphic facies of KOIDE (1958), the field of metamorphism was subjected in the early period to the movements obliquely crossing the trend of the Ryōke zone (NNE) and in the later period parallel to the trend (WSW). The Sagawa granodiorite is a synkinematic intrusive which intruded in a late phase of the early NNE movement.

GEFÜGE ANALYSES OF THE RYŌKE LAGEN-GNEISS AND GRANODIORITES IN THE YANAI DISTRICT, YAMAGUCHI PREFECTURE. Yoshihiko OKUMURA. Gefüge analysis was made for quartz, biotite, and plagioclase in the lagengneiss and the accompanying older gneissose granodiorites. The results revealed that in respect to the direction of the C axis of quartz, 1) proper siliceous lagengneiss does not exhibit a characteristic pattern and the degree of enrichment is low. 2) In langengneiss in which granitization has progressed, the degree of enrichment is high, and exhibits a symmetry almost monoclinic to the axial plane. 3) Gneissose granodiorite has symmetry and enrichment of the same degree as the granitized lagengneiss. The direction and arrangement of biotite are disturbed with the progress of granitization. In plagioclase, the twinning plane of albite is arranged parallel to foliation. It is considered that with the progress of granitization in the order of langengneiss \rightarrow granitized lagengneiss \rightarrow gneissose granodiorite, rocks increase in plasticity under shear conditions, become gradually viscous, and results in the formation of the above-mentioned fabric.

ON THE GRANITE AND METAMORPHIC ROCKS IN THE AREA NORTH OF NIINO, SHIMO-INA-GUN, NAGANO PREFECTURE. Yūtarō SAKAKIBARA. The granite in this area is divided into two types. One is coarse-grained and is called the Niino granite. The other is fine-grained granite called the Kadoshima granite. The Niino granite is (green hornblende-) biotite-granite having flow structure and is somewhat porphyritic; but in the parts near metamorphic rocks it becomes biotite-granite and where the granite is in contact with the metamorphic rocks, a crystal assemblage of garnet appears. The Kadoshima granite is (hornblende-) biotite-granite characterized by fine-grained porphyroblasts of microcline, of which the lithology is almost changeless, and plagioclase exhibiting remarkable zonal structure. The Niino granite, viewed from its chemical composition, is of the early Ryōke period corresponding to the Sumikawa granites, the Inagawa granites, and the Tenryūkyō granites in the granites of Central Japan. The Kadoshima granites are of the fore-Ryōke (pre-Ryōke type) corresponding to the Kurokawa type granite. Double metamorphism explained by andalusite + biotite + quartz \rightleftharpoons cordierite + water is thought to produce the cordierite (andalusite)-potassium feldspar-biotite hornfels in the Niino granite and the porphyroblasts of cordierite 2 millimeters long found around the Kadoshima granite.

GRANITIZATION OF THE RYŌKE ZONE IN MIE PREFECTURE. Hajime YOSHIZAWA. Folds: Over the minutely folded structure of the Paleozoic formation and included basic rocks a larger fold structure was formed. The formation of the large fold structure is closely related to the formation and intrusion of granite. In addition, there was a movement by which the central zone was formed. As a result, this area became an anticlinorium and was also thrust upward to the Sambagawa system. Granitic rocks: Mica-hornblende granite in the early period took the form of metasomatic or sheet intrusions, but the mica-hornblende granite of the later period is of the intrusive type. Through its entire lithofacies, however, the rock is subconcordant to the surrounding rock

ON THE RELATION BETWEEN THE TECTOGENESIS AND PLUTONIC IGNEOUS ACTIVITY IN THE KASAGI AREA, KYŌTO PREFECTURE. Ikuo HARA. The field of Ryōke metamorphism together with the Tamba zone in the Kasagi area

mass. In this area none is distinctly discordant. Meanwhile, banded intrusive gneiss was formed in the upper part. **Biotite:** By means of M. TATEKAWA's spectrographic analysis it was revealed that the rocks are rich in Al_2O_3 as compared with the rocks of the same character in the non-metamorphic zone, and the ratio of Fe to Mg changes remarkably even in one lithofacies. This supports a polution origin theory.

THE IRON AND MAGNESIUM CONTENT OF BIOTITE IN GRANITE. Masahisa TATEKAWA.

(I) **Tango-Okutango region:** The Mg and Fe content of small-sized biotite in granite of the so-called intrusion type in Gyōja-yama, Kameoka City, Kyōto Prefecture, and the Hiei-zan area was compared with that in the granite of the Ryōke type distributed in the Tanokami-Mikumo and Tanakura-Mizutori areas in the southern part of this region, and the Ueno-Tarao-Kosugi, Tsukigase, Kasagi and Mie areas. As a result, the following difference was disclosed. In biotite of the intrusion type, N is (where N is a sum in milligram of atoms of Mg and Fe contained in one gram of biotite) generally more than 5 and in biotite of the Ryōke type N is generally less than 5.

(II) Comparing the metamorphic siliceous conglomerate with biotite in the adjoining granite, the value of N in the former is strikingly smaller than in the latter. Considering that in the crystal lattice Mg, Fe and Al are exchangeable with one another among tetrahedral-Si sheets, the fact described in (I) must be considered to show that more Al exists between sheets in granite of the Ryōke type. This inference is supported by the fact described in (II)

This is evidence that the formation of granite of the Ryōke type is closely related to sedimentary rocks which abound in Al.

THE RELATION BETWEEN THE MIGMATITE AND THE GNEISSOSE GRANITE ON THE PIPAIRO RIVER IN THE NORTHERN PART OF THE HIDAKA ZONE. Seiji HASHIMOTO and Toshiyuki KOSAKA. Gabbro, granite, aplite, gneissose granite, cordierite-bearing biotite, migmatite, and gneiss are developed in the northeastern part of the Hidaka Mountains. From their mutual relation in the field the following consideration is possible: the formation of gneiss and migmatite \rightarrow intrusion of gabbro \rightarrow intrusion of gneissose granite \rightarrow intrusion of aplite dike group \rightarrow intrusion of granite. When the series of processes is built up as a development of structure, it is understood that as the last stage the formation of migmatite gives rise to granitic magma in the deep subterranean part.

GRANITIZATION OF CALCAREOUS ROCKS AND BASIC ROCKS IN THE HIDA METAMORPHIC ZONE. Takeshi AOKI. Calcareous rocks and basic rocks are abundant in the Hida metamorphic zone, so it is important to reveal the mechanism

of granitization, using these rocks as the original rocks. Based on observations in the field and laboratory, the rocks are divided into (1) the series of calcareous gneiss \rightarrow Ōtani gray granite, hornblende gneiss \rightarrow Ōtani gray granite and biotite gneiss \rightarrow Ōtani granite, and (2) the series of amphibolite \rightarrow nebula-like gneiss \rightarrow Iodani red granite, amphibolite \rightarrow gneissic diorite \rightarrow Iodani red granite. The changes of the principal constituents and minor elements, twins of plagioclase, and optical properties of hornblende and biotite were examined. Furthermore the principal constituents and minor elements of hornblende and biotite were analyzed, disclosing the relation between the chemical composition and optical properties disclosed.

DIFFERENCES AND SIMILARITIES BETWEEN MAGMATIC GRANITE AND GRANITE FORMED BY GRANITIZATION. Shinji SATO.

The former is called 1, and the latter 2.

(I) **Microscopic examination:** The texture of 1 is hypidiomorphic and granular. That of 2 is "egg-shaped sutured texture". Hornblende formed by polysynthetic crystallization is detected in 2, but not in 1. Carlsbad twinning of plagioclase is 15 to 30 percent ($An_{12} - An_{40}$) in 1, and is 0 to 5 percent in 2. The component difference of zoning of plagioclase of 1 is 15 to 25 percent An (granodiorite) and 0 to 5 percent (granite). Unit 2 scarcely exhibits zoning and slight zoning is rare (component difference 3 to 4 percent An). Liquid inclusions in quartz are found to some extent in 1 but are very scarce in 2.

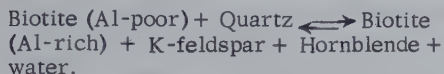
(II) **X-ray examination:** Plagioclase of 1 is usually of the "low temperature type" and sometimes of a "medium of high temperature type" (Tertiary quartz diorite), and that of 2 is mostly the "low temperature type" and rarely the "medium type" (originated from basic volcanics). Potassium feldspar in 1 is microcline-orthoclase and in 2 is close to maximum microcline ($4 = 9.0$ to 9.6).

(III) **Chemical composition:** Concerning K_2O/Na_2O ratio, 1 is 1.0 to 0.1 and 2 is less than 0.5. With respect to $K_2O + Na_2O/CaO$, 1 is 0.5 to 9 and 2 is less than 3, but is rather high as compared with 1 which contains SiO_2 . Hence, granite which is rich in Na_2O is abundant in 2.

ON BIOTITE IN GRANITE. Yasue ŌKI. The granite of the Ryōke zone abounds in Al_2O_3 and has normative corundum, but the granite of Shimonomoto, Funatsu, and Kisokomaga-take is poor in Al_2O_3 and has normative wollastonite. This difference may be mainly due to mafic rock minerals. The results of chemical analysis of the biotite which has been separated came out as expected.

When the bulk chemical compositions of the

biotite and its country rock are compared, the biotite of Kisokoma granite is too rich in Al_2O_3 as compared with the bulk chemical composition of its country rock. That is, on an AKF diagram the biotite is too near the biotite of Inagawa, Tsukuba, and Inada granites. This can be explained by the following formula.



When the pressure of H_2O is small (or at the time of high temperature), the combination of minerals proceeds to the right. This shows the pressure of water vapor in the Kisokoma granitic magma was small as compared with the Inagawa, Tsukuba, and Inada granitic magmas. From the bulk chemical composition of granite and the chemical composition of biotite, the intensity of pressure of water vapor of the magma can be compared.

GRANITIZATION AND DISTRIBUTION OF RADIOACTIVITY. Susumu NISHIMURA and Jin'ichirō HATSUDA. The distribution of radioactive elements in granite bodies shows a distinct tendency, particularly within that narrow part where the granite bodies are in contact with the adjoining rocks. The granite bodies were classified into four types based on this tendency. However, this classification was made for the purpose of explanation, and actually there are also continuously intermediate types. It seems inferrable that the tendency is determined by the P-T condition at the time the granite was formed. From the standpoint of thermodynamics also, the tendency conceivably shows the conditions of granite intrusion, that is, it shows the degree of fusion in which the granite was formed. Judging from this, the intrusion of granite seems to have occurred under various conditions, ranging from a mostly fused condition to an almost solid condition. By pursuing this problem from various angles interesting results can probably be obtained.

GRANITIZATION AND ZIRCON. Yoshibumi KARAKIDA and Tōru TOMITA. From past experience, it is conceivable that the character of zircon, which is a secondary constituent of granite, reflects fairly sensitively the physico-chemical environments at the time the granite was formed. Zircon in granitic rocks that are regarded to be products of granitization, therefore, is expected to have a character different from that [of zircon] in common intrusive granite, and a thorough study of this zircon probably could contribute to disclosing of the granitization process. With such an expectation, the writers systematically examined crystal grains of zircon that had been separated from a series of rocks in the Ryōke zone in the Yanai district, — non-metamorphic sedimentary rocks, gneiss and granite closely associated with gneiss. The results reveal that the char-

acter and particular habit of zircon in the rocks formed in connection with granitization, and, in addition, the zircon has a characteristic distinct from that of intrusive granites. From the above character, it was suggested that the process of granitization may be exceedingly complex.

ON THE POSSIBILITY OF FORMATION OF GRANITIC PRIMORDIAL MAGMA. Masao GORAI. Based on a new theory of the earth's genesis, which had rapidly developed after the war, and a structural theory of the earth's interior on the basis of the latest geophysical data, the writer studied the origin on the continental crust (granitic crust) and reached the following conclusions.

1) The principal body of acidic rocks constituting the granitic crust was formed by neither the so-called "dry granitization" nor "wet granitization".

2) The ultimate origin of the above acidic rocks in granitic primordial magma derived selectively from ultrabasic substances existing under the Mohorovičić discontinuity.

3) SiO_2 which is the principal constituent of granitic primordial magma is considered to have been produced by dissociation of pyroxene and olivine which constitute the above ultrabasic substance under high pressure at depths several tens to several hundreds of meters.

Discussion:

(1) The results of experiments under the pressure of water vapor, recently carried out by Bowen-Tuttle, have been applied to granite and metamorphic rocks. This fact was discussed. Yasue ŌKI asked about the treatment of mafic minerals in the triangular diagram in the lecture delivered by Yoshio SUZUKI. Kenzō YAGI pointed out that the contaminated rocks in Hidaka fall at right angles to the valley connecting the Yoder's diagram with the Tuttle's diagram. SUZUKI answered the question. Next, the lecturer expressed his opinion that the granites southeast of Kōfu, may have originated from the refusion of spilitic rock and sedimentary rock in the green tuff. K. YAGI inquired of the lecturer as to whether or not such an inference can be made only by the chemical composition. Y. YAGI answered that not only are the rocks rich in Na_2O and poor in K_2O but that normative Co is detected, and if the fact that trondhjemite in Tanzawa is rich in Na_2O is due to large pressure of water vapor, a strikingly large water vapor pressure must be assumed in the case of rock such as that in Ashikawa which contains particularly abundant Na_2O . Shūichi IWAO and Kenji WATANABE inquired of ŌKI concerning the grounds of refusion. ŌKI answered that the part which corresponds to geosyncline is favorable to refusion, but there is no confirmative evidence.

Moreover, in answer to SŌMA's question ŌKI told him that the rocks in Tanzawa are different in character from those in Kōfu in respect to the presence of zeolites, etc.

(2) Various opinions on the definition of granitization were expressed. Shinji SATŌ proposed that granitization must be distinguished from hybridization and contamination. Nobuhide MURAKAMI pointed out that there is granite which was formed by metasomatism in the Hiroshima granite, and he hoped that this also would be called granitization. Hajime YOSHIZAWA stated the following opinion. Almost all the constituents of granite in the Ryōke zone in Mie Prefecture originated from magma, so it can be expressed by the term contamination. There is no reason why it must be called granitization. He proposed that the isochemical case in which constituents do not come from the outside, and no fusion takes place must be called granitization. Seiji HASHIMOTO said that the Hokkaidō University adopts the term migmatization in a wider sense and that there are changes in the kinds of minerals due to tectogenesis, and that the formation of granite at depth cannot be separated from migmatization near the surface. Masao GORAI expressed the opinion to the effect that, even if the term is strictly defined, it cannot be used in the field work. George KOJIMA's opinion was as follows: Descriptive matter and chemical composition have been discussed thoroughly 20 years ago. Hereafter it is necessary to collect additional data on rock minerals and the criteria for zoning gneiss and granite must be revised again. Tōru TOMITA enumerated the foreign usage of the terms granitization, migmatization, and contamination, and said that "granitization" used in Japan is applied on a small scale, so it cannot be treated in the same way as "granitization" in foreign countries. YAJIMA proposed the use of rock names not involving the origin in the case when the origin is not known. This proposal was supported by many attendants, but they agreed in the respect that further consideration would be necessary to realize this proposal. All attendants hoped that a similar discussion could be held every year.

Bedded Metalliferous Deposits of Japan

Subject of discussion: How can we determine whether bedded metallic deposits are syngenetic or epigenetic?

There are many bedded metalliferous deposits such as some manganese deposits, manganese iron deposits, and black ore deposits. The genesis of these ore deposits has been discussed frequently by many geologists. Most frequently discussed is the problem on whether these ore deposits are ore beds or metasomatic deposits.

Though each ore deposit may involve various problems, whether the deposit is syngenetic with the country rock or epigenetic is a problem which

becomes the object of discussion common to all cases.

The old-fashioned ore bed theory on kieslager² and manganese ore deposits has gone out of fashion and the metasomatic theory has become predominant. Quite recently, in mineralogical circles of the world, the fact that the ore bodies are stratified and conformable has been frequently discussed along with the relationship between ore deposits and basic igneous activity in the geosyncline zone. There are not a few geologists who classify ore deposits into "submarine volcano fumarolic ore deposits or hot spring precipitation ore deposits". Such views on the genesis of ore deposits are important problems which affect prospecting.

Under such circumstances this debate was scheduled in cooperation with the Mining Geological Society of Japan.

The debate began at 9:00 a. m. and ended at about 6:00 p. m. After the debate, T. WATANABE summarized the discussions and pointed out problems to be studied in the future. Based on the problems, the future course of study was discussed ardently for about one hour and a half. The problems were as follows:

1. The stratigraphic position of bedded metalliferous ore deposits.
2. Local characteristics of each ore deposit.
3. The relation of bedded metalliferous ore deposits to ore veins.
4. The relation of bedded metalliferous ore deposits to igneous rocks.
5. The relation of bedded metalliferous ore deposits to sedimentary country rocks.
6. The relation of bedded metalliferous ore deposits to metamorphism.
7. The relation of bedded metalliferous ore deposits to metasomatism

VARIOUS VIEWS ON THE GENESIS OF BEDDED SULFIDE DEPOSITS. Manjirō WATANABE. Formerly the precipitation theory had been extensively followed to explain the genesis of bedded sulfide ore deposits, and at the end of the 19th century the submarine eruption theory and the steam intrusion theory appeared. After that, the hydrothermal metasomatic impregnation theory became predominant. However, thereafter the submarine eruption theory and the

²The term "kieslager" is probably equivalent to sulfide deposit(s) throughout.--E.I.

dynamometamorphic theory were repeated from a new standpoint. Discussions of the problem have been particularly active in the last twenty years, taking into consideration sea-bottom deposition related to basic eruptions in the early period of the cycle of subsidence of geosynclinal-orogenic movements, and the migration of constituents accompanying regional metamorphism in the middle period.

For example, in the Hitachi ore deposits the following succession is considered: the formation of pre-orogenic sulfide deposits in the sea-bottom (surface or shallow subsurface layer) accompanying the submarine volcanic activity of the Gozaisho system in the subsiding part of the Abukuma geosyncline with the Carboniferous as the center (in time); the later co-orogenic deep-seated metamorphic differentiation or the secondary hydrothermal migration accompanying the probable Permian-Triassic orogenic movements, and the post-orogenic, local steam-hydrothermal metamorphism accompanying the formation of the post-Cretaceous granitic batholith. Though the conditions in the early period are not known, the deposits possibly originated from sulfide deposits of the black ore type or the Matsuo type in the Uetsu geosynclinal zone.

MANGANESE DEPOSITS. Toyofumi YOSHIMURA.

(1) Manganese ore deposits of which the genesis has been clarified.

- (i) Ore beds of Miocene, Tertiary (sea-bottom steam type) Pirika type.
- (ii) Ore veins in the altered layers of volcanics of Miocene, Tertiary Inakuraishi type.
- (iii) Various metamorphosed ore deposits Muramatsu type (dynamometamorphism), Yakeno type (thermal metamorphism), Ioi type (hydrometamorphism).

(2) The genesis of the manganese ore deposits in the Paleozoic formation, particularly the genesis of the Tomisato, Anauchi, Kitami, Yamato, Kaso, and Manako types is the most difficult problem. Even if the deposits are considered sedimentary ore deposits or metamorphic ore deposits, sedimentation or metamorphism quite different from the above-mentioned cases and fanciful in a certain sense must be assumed.

If the deposits are considered metasomatic ore deposits, in respect to mineral solution which caused mineralization, very peculiar character must be assumed, such as

- (i) low temperature in the early period,
- (ii) high temperature in the upper part and low temperature in the lower part,

(iii) dry early period and wet later period,

(iv) abrupt mineralization.

(3) History of the views on the genesis of manganese ore deposits.

- (i) Ore bed theory,
- (ii) open-air residual theory,
- (iii) metasomatic manganese oxide theory,
- (iv) ore vein theory,
- (v) metasomatic ore deposit theory, and
- (iv) redeveloped ore bed theory.

MANGANOMAGNETITE DEPOSITS. Akira TAKAHATA. The genesis of manganomagnetite deposits of Japan is explained by the syngenetic theory of M. WATANABE and the epigenetic theory of Toyofumi YOSHIMURA and Hideki IMAI. The writer, as a result of the study of almost all manganomagnetite deposits known up to the present, reached the conclusion that the deposits are syngenetic and were deposited from hot springs issuing from the sea-bottom. The main grounds of his conclusion are that the deposits are in the same horizon; diabase (basalt) with a close genetic relation with the ore deposits effused as lava from the sea-bottom; the deposits are always conformable with the over- and underlying rock layers; various depositional textures in the ore (colloidal structure, banded depositional structure, oolitic structure, spherulitic structures, ophthalmic structure, etc.) are found, in spite of the absence of evidence confirming metasomatism; and mineral composition of ores is generally simple. Furthermore, diagenesis contributed to the formation of part of the constituent minerals and some textures seen in ores. Secondary enrichment common to ore deposits of the Lake Superior shore type, however, is not seen.

WATER-STRATIFIED METALLIC ORE DEPOSITS FORMED AT THE BOTTOM OF THE TERTIARY SEA. Ryōichi ŌHASHI. Briefly speaking, these are ore deposits of the black ore type. The writer refrained from using the words "black ore" as this frequently causes misunderstanding. This is a stratified yellow ore deposit part of which is accompanied by black ore. The black ore is enveloped by the yellow ore which is spheroidal, platy, funnel-shaped, or of irregular large and small blocks. The black ore without exception is underlain by the ore deposits and overlain by the yellow ore and passes gradually into the impregnation of iron pyrite or a reticulated fine vein assemblage.

The overall shape of the ore deposits is

stratified and one or several limbs extend downward. The deposits from which the stratified parts have been eroded and only limbs remain are described as massive ore deposits with large heads and small tails.

Most of the ore deposits fill depressions formed by explosions in the later period of the activity of Tertiary submarine volcanoes, and were deposited in irregular stratification. Abundant explosion breccias were embraced, parts of deposits have grown in the form of concretions, and sometimes metasomatism is remarkable in the lower part (parts of limbs, etc.). The deposits are underlain by andesite or rhyolite or its tuff and tuff breccia which was effused on the sea-bottom, and the ore deposits constitute part of submarine volcanic bodies.

The nature of the hydrothermal solutions changed with different periods. In the early period the solutions were neutral or weakly alkaline, high in temperature, and crystallized the yellow ore. In the later period, however, the solutions became gradually acidic, crystallized zinc-blende, barite, and gypsum, and formed black ore. This change is quite the same as the change of nature in the hot springs distributed in the present volcanic zones.

Ore veins underlie the stratified ore deposits. The country rocks are mostly hard mudstone and tuff belonging to the Onagawa beds, and sometimes the country rocks are beds (basement) lower than the above rocks, or andesite, propylite, and rhyolite constituting part of submarine volcanic bodies. In these cases the ore veins are in almost the same horizon as the black ore deposits.

SOME NOTES ON A KIESLAGER-LIKE ORE DEPOSIT IN THE NONMETAMORPHIC GROUP OF UNKNOWN AGE IN THE KII PENINSULA. Isao SHIIDA and Kōshirō UMEDA. The group of formations south of the Mikabu line in the central part of the Kii Peninsula is divided from north to south into the Sarutani group (a) and the Ōmine group (b), the Uenoji beds (c), the Oritate beds (d) and the Higashimuro beds (e). Of these, the three beds that contain ore deposits shown in the title are beds (a), (c), and (d). Particularly prominent is (a), one deposit of which is the Kanayabuchi ore deposits. The "ore deposits" in each bed are generally accompanied by strata of green rocks (mostly spililitic basalt), chert, "tuffaceous shale", etc. This suggests a close relationship between submarine volcanic activity of some kind in the geosyncline and the formation of ore deposits. Moreover, summarizing the results of latest research, that differs from previous concepts: (a) lies conformably under (b) which contains Fusulina, and (a) is considered to belong to the Chichibu complex. Though green rocks and abundant chert are contained in (b), no ore deposits are

found at all. Whether or not the difference is due to 1) different age, 2) different sedimentary condition, or 3) different area cannot be determined. The writers expect that 1) and 2) are more possible.

[Discussion]

KANO: What is the difference between this report and previous reports: In previous reports, the Sarutani beds were assigned to the Mesozoic.

Answer: Later study confirmed that the Sarutani beds belong to the Paleozoic.

KANO: The ore deposits in the Gojō mine are situated on both sides of the Butsuzō line. Are these of a different horizon?

Answer: Yes.

THE RELATIONSHIP BETWEEN ORE DEPOSITS AND METAMORPHISM (Summary). Hiroshi KANO. In the kieslager of all types, from the non-metamorphic zones such as Gojō and Tokura to the highly metamorphic zones such as Besshi and Sazare, the following genetic conditions are pointed out.

1. Geosynclines and orogenic zones in which ore deposits occur are located in the foremargin of an orogenic zone having a granite zone as an axis.

2. Dynamic action (folding, fracturing, and shearing) was exerted intermittently in the area for a long time (for a short time in the case of younger shallow geosynclines) from the period of geosyncline formation to the orogenic-metamorphic period.

3. In connection with this, various igneous rocks (diabase, gabbro, porphyrite, keratophyre, etc.) which were the source of metallogenetic elements were erupted and intruded.

In short, it is considered that ore deposits are dynamic metamorphic ore deposits formed simultaneously as the dynamic action in the above sense, and, in respect to the genesis of metallogenetic elements, some are syngenetic but the most are epigenetic.

[Discussion]

ISHIKAWA: You said that metals were supplied by dynamic action. Aren't metals accompanied by igneous activity?

Answer: Igneous activity is accompanied by dynamic action and the igneous activity is accompanied by metals.

ISHIKAWA: Is this region different from Tertiary green tuff region? I think that there is

similarity in the genesis of ore deposits corresponding with similarity of green tuff, propylite, and green schist. Don't you think so?

Answer: They are quite different essentially in the respect of presence or non-presence of dynamic action. This may be due to the character of a geosyncline. Force was exerted from one direction in the Mesozoic and Paleozoic geosynclines, and upheaval and subsidence of the basement were the principal action in the Tertiary geosyncline.

ÔMACHI: What is the source of the metals?

Answer: It is the post-action of igneous activity that accompanied the dynamic action.

T. WATANABE: You say that the ore deposits in Iriyoma are of fracture type. In respect to this problem it is necessary to make further graphic examination to distinguish the two kinds of ore.

DISTRIBUTION OF THE MINOR ELEMENTS IN SULFIDE MINERALS IN SOME BEDDED COPPER-BEARING PYRITE DEPOSITS. Hideo MINATO. Principal ore minerals which occur in the so-called kieslager are poor in variety, and the fact is one of the difficulties on the study of ore deposits. The writer is studying the distribution of minor elements of ore minerals as a method of investigation. The method is an application of partial spectroscopic analysis, by which minor elements can be detected from an area 0.1 mm in diameter on a polished fragment. Minor elements detected from pyrite and chalcopyrite from the Besshi mine are As, Ag, Pb, Mn, Cu, Zn, Ni and Co. It was found that two elements, Ni and Co, have a tendency to concentrate where the bedded ore is in contact with rocks. With this phenomenon in mind, the writer collected ore which had occurred between the hanging- and foot-walls at two localities of the Naai ore deposits, Kunemine, and examined the minor elements. The minor elements detected are Sb, Sn, Ag, Pb, Mn, Cu, Zn, Ni, Co, Cr and Ti. At one locality, the four elements, Ni, Co, Cr and Ti, have a tendency to concentrate in ore minerals close to the foot wall. The elements, Ni, Co, and Ti are distributed also as minor elements in rocks which are in contact with the ores.

[Discussion]

ARITA: Doesn't the distribution of Ni and Co become asymmetrical to the hanging- and foot-walls of the ore deposits?

Answer: At the lower No. 4 adit of the Kam-paki ore deposits in Naai there is one example.

Problem on the Boundary between the Cretaceous and Tertiary of Japan

This symposium was proposed in connection

with items for presentation at the International Geologic Congress of 1960. The contents of lectures delivered are published in "Foraminifera" nos. 10 and 11. Questions and answers also are published in detail in no. 11 of the above publication.

ON THE DIVISION BETWEEN THE UPPER CRETACEOUS FAUNA AND THE EOCENE FLORA OF JAPAN. Toshiji ÔYAMA. As published in the Journal of Ibaraki University, the Ôarai flora of the Upper Cretaceous consists of 50 genera and 61 species at present. However, it has been objected that the structural relation between the Ôarai fauna and the ammonites zone of the Nakaminato beds is not confirmative as they are separated by the Naka River. Therefore, the writer intends to compare the Ôarai flora with the Paleogene flora of Japan from the standpoint of plant constitution and to clarify the division.

In the Paleogene floras in the provinces north of the Kantô district, the flora which contains abundant genera and species and is most reliable as a representative of the botanical region is the element of the Ishikari group. The characteristic species in the Ishikari group, beside *Myrica* and *Acer* are monocotyledons such as *Potamogeton*, *Carex*, *Musa*, and *Sabal*, which are contained in pollens in the Eocene Noborikawa beds in the lowest part of the Ishikari series. These fossils have not been reported from the Upper Cretaceous of Japan, and they can be regarded as characteristic species of Eocene plants in Hokkaidô. These fossils have not been detected from the Ôarai flora. By the above fact the Ôarai flora must be distinguished from the flora of the Ishikari series in respect to the constituent elements. On the other hand, *Otozamites* in the Ôarai flora is a genus characteristic of the Tamagawa beds and the Kadonosawa beds of the Kuji group in the Kuji district, Iwate Prefecture, and it is a Mesozoic genus which is found in the beds above and below the *Inoceramus japonicus* zone. Moreover, the Ôarai flora contains Mesozoic fossils such as *Neocalamites* cf. *brevifolius* Sze. As already reported, though the Eocene elements of the Ôarai flora are 21.3 percent and the Upper Cretaceous elements 16.4 percent, the age limit shown by the characteristic fossil cannot be considered younger than the Upper Cretaceous. Judging from the data throughout Japan, the Upper Cretaceous flora of Japan is considered to be characterized by a consistent series of closely related species in the beds above and below the *Inoceramus japonicus* zone of the Kuji group and in the beds above and below the *Cirroceras-Nostoceras* zone of the Nakaminato group.

THE BOUNDARY BETWEEN THE CRETACEOUS AND THE TERTIARY VIEWED FROM SMALLER FORAMINIFERA. Yôkichi TAKAYANAGI. Planktonic species are more useful than benthonic

species for the purpose of age determination and correlation of extensive regions by means of Foraminifera. From planktonic species, it is reasonable to assign a Maestrichtian [age] to the uppermost stage of the Cretaceous and a Danian (= Montian) [age] to the lowermost stage of the Tertiary. There was a remarkable change of foraminiferal fauna in a period between Maestrichtian and Danian. Danian was a period when planktonic Foraminifera declined from Cretaceous to Tertiary. The stages before and after Danian are represented by characteristic fauna due to the appearance and disappearance of species of planktonic Foraminifera, and the stages coincide with the zones.

In Japan, planktonic Foraminifera of the Maestrichtian stage are scanty. Foraminifera fauna corresponding to the Paleocene series has not been discovered. Foraminifera fauna of the Eocene series overlaying the Paleocene was discovered only in Amakusa, Kyūshū. For this reason there is no datum to confirm the boundary between the Cretaceous and Tertiary at present. Future studies of this line are especially desired.

In the Tonnai beds of the layers developed on the Kuruki River in Noborikawa which have been regarded as the Hakobuchi group by OTATSUME and others, are found planktonic Foraminifera fauna of the lower Hetonai stage, which are extensively distributed in the axial part of Hokkaidō. Nevertheless, in a series of layers from lower sandy siltstone to the Sanushuppe beds, a benthonic Foraminifera fauna which is entirely different from that of the underlying Cretaceous and is rather regarded as the Horonai type appears, but planktonic Foraminifera are not found at all.

Questions: K. ASANO asked the attendants' opinion on whether or not there is room to re-examine the stratigraphy of the area near Noborikawa. W. HASHIMOTO and Y. KANAI answered that they had no doubts on the stratigraphical survey by OTATSUME, but agreed that a revision of details may be necessary. A. MIZUNO inquired about the basis for the conclusion that the Cretaceous in the vicinity of Kushiro viewed from Foraminifera is upper Maestrichtian-Danian. The writer answered YOSHIDA that as the elements for age determination are scanty, except for "Globigerina" sp., he could not reach a conclusion.

THE BOUNDARY BETWEEN THE CRETACEOUS AND THE TERTIARY IN HOKKAIDŌ. Yasuo SASA and 20 others.

1. As far as is now known, the uppermost part of the Cretaceous of Hokkaidō is a layer corresponding in the upper Senonian (probably Maestrichtian stage) and the lowermost part of the Tertiary is the middle and lower Eocene. Confirmable Paleocene has not yet been discovered. Therefore, no particular contribution

can be made to the Danian problem.

2. In the northern half of the Ishikari coalfield, the Hakobuchi group, which occupies the uppermost part of the Cretaceous, has been eroded gradually toward the south, and is in contact with the Noborikawa beds which constitute the lowermost layer of the Tertiary. In the central western part, erosion progressed from the Urakawa group to the Mikasa group and the groups are immediately overlain by the Ikushumbetsu bed, which is the upper part of the Ishikari group. The eastern part of the southern half resembles the eastern part of the northern half, but in the western part the Hakobuchi group is truncated and the beds belonging to the Urakawa group are in contact with the middle and lower beds of the Ishikari group, the relationship being covered westward. In the southern part of the southern half, the Ishikari group has been eroded almost completely and the overlying Horonai group is directly in contact with the Hakobuchi group or the Urakawa group.

3. In the Rumoe coalfield, the upper Urakawa group is covered by the Shiraki beds corresponding to the Wakanabe beds. In the northern part, erosion proceeded gradually to the lower layer, and it is in contact with the Sasakizawa beds which is the lower Miocene.

4. In the Kushiro coalfield, the various beds of the Nemuro group corresponding to the Hakobuchi group are overlain by the Urahoro group corresponding to the upper part of the Ishikari group.

5. In every area, though the Cretaceous seems locally to be para-unconformable with the Paleogene, generally speaking, it is evident that they are in gently inclined unconformity. The contact of these two systems suggests that after the deposition of the Cretaceous formation, very gently changes occurred, and after having undergone gentle folding the systems suffered extensive peneplanation, then the sedimentary basin in which the Paleogene formation was deposited was formed, burying the formerly existing marine basin.

6. In the Kushiro and Rumoe coalfields, the boundary between these two systems can be seen distinctly by a basal conglomerate in most cases. However, in the Ishikari coalfield, the boundary between the two systems frequently blends so that it cannot be defined clearly.

7. In respect to flora, the flora of the Hakobuchi group is common to the flora of the Noborikawa group in not a few cases, but on the other hand fairly remarkable differences are pointed out. There are not a few main points which do not appear in the Paleogene formation.

Ammonites and *Inoceramus* do not appear in the Tertiary except where they have been re-

worked (Example -- the base of the Horonai beds in the Hobetsu district). Foraminifera and mollusks occur in the Hakobuchi group, but they do not occur in the Noborikawa beds in the base of the Paleogene, so there is no basis for discussing the difference between the two. Consequently in Hokkaidō, stratigraphically and paleontologically it is a problem to determine whether a certain bed belongs to the Cretaceous or Tertiary. On the so-called Danian problem, the writers have nothing on which special discussion is made.

BIOSTRATIGRAPHIC DIVISION (OF THE UPPER PART OF THE UPPER CRETACEOUS) BASED ON FOSSIL PELECYPODA. Kōichirō ICHIKAWA and Yasuo MAEDA. The Izumi group in the type locality of the Izumi Mountains and Awajishima corresponds to the upper series of the Upper Cretaceous (Hetonai series + ? the uppermost stage of the Urakawa series). Its rich fossils serve to characterize the uppermost part of the Cretaceous. Based on more than 60 species of bivalves (list is omitted), three biostratigraphic units were found in the Izumi group (I, II and III in ascending order). According to the correlation based on ammonites and *Inoceramus*, units II and III correspond to the upper stage of the Hetonai series and unit I is lower than units II and III. Unit I is characterized by varieties of *Inoceramus balticus*, species of *Apiotrigonia*, and *Portlandia furcata*, unit II by *I. shikotanensis* and species common to units I and II but unknown to unit III (*Micronectes bellaturus*, etc.), and unit III by *Inoc. awajiensis*, *Portlandia cuneistriata*, *Eriphyla elegans*, etc. (Description and horizon of each species will be published in the Journal of Osaka City University, 3, 4 and subsequent volumes.) It is noteworthy that two biostratigraphical units based on bivalves, are noticed in the upper stage of the Hetonai series in the Izumi group. Finally the writers emphasized that the Izumi group contains abundant specialized genera of the Mesozoic type belonging to families which became differentiated and developed in the Mesozoic era and became extinct or abruptly declined in the Cenozoic era such as the *Inoceramids*, *Apiotrigonia*, *Pleurogrammatodon*, *Nanonavis*, and *Indogrammatodon*.

THE BOUNDARY BETWEEN THE CRETACEOUS AND THE TERTIARY IN AMAKUSA-SHIMOJIMA. Nobuhiro HATAE. The Cretaceous in Amakusa-shimojima entirely belongs to the Himenoura group and can be divided into six parts based mainly on petrographic character, designated parts H_1 - H_6 in ascending order. Each part yields fossil shells; part H_5 yields many species of fossil shells. The Himenoura group in Amakusa-shimojima has been correlated with the Urakawa series. However, based on fossil species, etc., in Koshiki-jima it is considered that at least parts H_4 - H_6 correspond

to the upper half of the older Hetonai series as proposed by MATSUMOTO and AMANO.

Considering that the lower half of the Tertiary (corresponding to NAGAO's Yautsubo and Hontō groups) represents a cycle of transgression and regression, the lower half was summarized as the Shimojima group; the name "Fukami sandstone" [in this group] is not reasonable as it is imperfectly developed in the type locality, so the name was changed into the Akashimisaki beds. The upper part of the Akashimisaki beds is intercalated by a *Nummulites* zone which yields abundant *Nummulites*, *Discocyclina*, etc. It is considered that the upper part corresponds to the lower Lutetian or Cuisian. The writer explored the southern half of Amakusa-shimojima and the adjoining islands, and found that the sedimentary facies shows a gradual change of sedimentary environments from south to north and also indicates the direction of transgression.

Amakusa-shimojima, where the upper half of the marine lower Hetonai series is directly overlapped by the lower part of the Eocene series, is considered to be a suitable area for the purpose of disclosing the stratigraphic relation between the marine Cretaceous and the Paleogene in Japan.

The boundary between the Upper Cretaceous (Himenoura group) and the Paleogene (Shimojima group) was revealed to be a clino-unconformity on Shimojima and the adjoining islands. Under the unconformity a remarkable denudation of layers is observable. Therefore, it must be recognized that crustal movements which accompanied folding and a long period of denudation occurred between the Upper Cretaceous and the Paleogene, and the period is considered to have been after the later period of the older Hetonai epoch (Maestrichtian-Campanian) and before early Eocene (lower Lutetian-Cuisian).

Question: T. MATSUMOTO: Why did you determine the *Nummulites* zone to be the Cuisian?

K. ASANO: Because the *Nummulites* are of a more primitive type than those of the Bonin Islands.

PROBLEM ON THE BOUNDARY BETWEEN THE CRETACEOUS AND THE TERTIARY VIEWED FROM INTERNATIONAL CORRELATION. Tatsurō MATSUMOTO. The latest knowledge on this problem in foreign countries was stated and the data on Japan were discussed.

(1) It is difficult to correlate directly the stratigraphy and index fossils in the type localities (of Northern and Western Europe) with those in Japan.

(2) The view that the Danian is assigned to the lowermost part of Tertiary based on Foraminifera

fera is predominant. The index cephalopod *Hercoglossa danica* is serviceable to the problem.

(3) In Japan *H. danica* and foraminifera peculiar to the Danian stage are not confirmed.

(4) In the Tethys Sea area there was continuous deposition of the Cretaceous and the Tertiary, but the stages in the boundary part can be determined based on fossils.

(5) The boundary between the Cretaceous and the Tertiary in the areas on the Gulf of Mexico and in the inland areas in North America has been confirmed quite recently. In respect to plants and land animals, however, the lag of the periods of appearance and disappearance between different areas cannot be neglected. Therefore, particular attention must be paid to the correlation between Japan and Pacific coast areas.

(6) The results of the latest research on the Pacific coast (California), North America, was reported. In respect to the correlation between the Pacific coast of North American and Japan, it is possible that the uppermost part of the Cretaceous can be correlated on the basis of Ammonites. In respect to the boundary area, however, it is necessary to advance the study in Japan by means of planktonic foraminifera.

(7) The study of corals, echinoids, brachiopods, calcareous algae, and pollen is also necessary hereafter. Study on these lines will contribute to the correlation between Japan and India as well as Madagascar.

In discussion following the paper, the writer stated that the technique of age determination of formations (K-A method, etc.) is progressing and data from this aspect are important to this problem; the writer strongly maintained that, as Japan is fairly rich in data, the study of this aspect must be promoted.

Outline of summary discussion:

Tatsurō MATSUMOTO, chairman, invited the attendants to discuss the aim of this symposium and told them that they might ask any questions they might have on local problems.

Tokio SHIKAMA questioned the relationship with the International Geological Congress and the procedure [to be followed]. Tatsurō MATSUMOTO and Teiichi KOBAYASHI answered the question. Their explanation disclosed that there is no way except the method described later on in order to take part in the congress.

Hisakichi HISAZUMI asked a question concerning the boundary problem in America and international correlation. Tatsurō MATSUMOTO explained the latest progress and Yasuo SASA introduced data on the Paleocene in California. Then, among Wataru HASHIMOTO, Hisakatsu

YABE, and Tatsurō MATSUMOTO discussed the results of this symposium and the future of the Danian problem. They stated, judging from the data delivered in this symposium, there are problems to be studied on the eastern part of Hokkaidō, the Ishikari coalfield, the Jōban coalfield, and Amakusa, and that it is necessary to promote the future study in the Outer Zone of Southwestern Japan.

Applied Geology

This symposium was held for the purpose of giving a chance for discussion of common subjects. This symposium was divided into 1) General applied geology and 2) the relationship between the land-creep zones in Japan and geology.

A lecture on the subsidence of the ground in Niigata City (Ryūji SUGIYAMA) was suspended, but Matsuji HUAKUTAKE delivered a lecture of which the content was almost the same as SUGIYAMA's lecture. HYAKUTAKE's lecture is abstracted below.

Matsuji HYAKUTAKE: According to measurements during the period from February to October, 1958, the subsidence of the ground was 1.4 mm in maximum per day.

AN EXAMPLE OF THE DECREASE OF YOUNG'S MODULUS OF A ROCK MASS DUE TO WEATHERING. Tōru ONODERA and Shin'ichi KUDŌ. Young's modulus of a rock mass was measured under the same conditions before and after consolidation grouting carried out on the left bank of the Ryohoku Dam in the Aya River, Miyazaki Prefecture. The rock mass in this locality is a rather siliceous shale of unidentified Mesozoic. According to the observation of the excavated wall, though the mass has been crushed by faults, etc., it is black to gray in color, fresh in appearance, consists mainly of quartz, chloritic mineral, and calcite, and the hardness is 3 to 4 as a mass and 4 to 5 as a rock. YOUNG's modulus was measured in a part 5 to 10 m from the surface of the mass plane in September, 1958, grouting was carried out in October, and remeasurement was made in November. The results revealed that Young's modulus which ought to be increased by grouting decreased in more than one-half the cases measured. The surface of the mass assumed a brown color from that observed in September, and the discoloration was particularly remarkable along the fissures. In addition, the fissures opened and fragmentation increased. That weathering has progressed mineralogically as compared with the fresh part was noticed under a microscope by the facts that iron saponite and iron oxide had been formed and the crystals of calcite had become indistinct. It is believed that physical and chemical weathering progressed more rapidly due to the loss of clayey substances, which had filled the fissures,

and that the formation of the above minerals along the micro-fissures, caused a decrease of YOUNG's modulus.

SURFACE GEOLOGY AND SOILS. Yoshio KATŌ and 2 others. The survey by the writers singly or jointly disclosed that survey of surface geology as a basis for a soil survey has an applicable value and at the same time serves to reveal the sedimentation process of alluvial formations and past volcanic activities. The writers intend to show the necessity of a detailed survey of the surface layer several meters thick of the alluvial formation, etc. For example, in the lowland of Tanabu in the Shimokita Peninsula, the formation and development of the alluvial lowland determine the kind and distribution of soil groups. In the Ukishima-bara peat land, Shizuoka Prefecture, the layer which is in contact with the peat bed is related to the kind, physicochemical properties, and productivity of the rice-paddy soil. In the drainage basins of the Ōi and Kiku Rivers in the same prefecture the amount of irrigation water for rice-paddies is controlled by the mode of sedimentation of the alluvial formation. In the western foot of Fuji-san, the kind (hardness) and distribution of "Masa" soil are determined by the sedimentation sequence of volcanic ejecta. In the Omae-saki tableland in the same prefecture, the geology of the lower layer exerts influence on the amount of irrigation water for the farms consisting of eolian sandy soil. The above-mentioned examples show that the knowledge of surface geology is necessary to productivity, land improvement, and irrigation.

Problems on the Quaternary in Japan

COLLECTING EMBAYMENT-TYPE FOSSIL SHELLS IN THE QUATERNARY BEDS OF SOUTHERN KANTŌ. Torū MAKINO. The fossil assemblages from the lower part of the Quaternary system distributed in southern Kantō generally consist of the elements of a non-bay facies, but those in the middle and upper parts consist of the elements of an embayment facies. In most localities the elements of the cold current system are considerably abundant, but on the other hand, fossil assemblages which contain a very few or no cold current elements, like the Toyonari and Tokumaru shell beds, have been reported. Judging from the fact that the fossil assemblage in Sakurai, Kisarazu City, which the writer considers to be lower than the Toyonari shell beds contains hardly any cold current elements, the writer pointed out that rather cold and rather warm sedimentary environments were repeated at least twice in the [early existence of] Paleo-Tokyo Bay, and stated that these environmental changes are also considered to exist in the stratigraphy of fossil assemblages of the bay type in the lower part of the Quaternary system in southern Kantō. From this point of view, he regarded the Shimosueyoshi

beds, the Sakurai shell beds, and the Semata shell beds as the same horizon. The Shimosueyoshi beds seem to have been considered conformable with the Shimosueyoshi loam beds, but the writer supposes that there was a lapse of time between the deposition of the two beds, and consequently the above correlation is reasonable.

CHANGES OF WATER TEMPERATURE INDICATED BY FOSSIL MOLLUSCA FROM THE STRATA NEAR THE BOUNDARY BETWEEN THE PLIOCENE AND THE PLEISTOCENE IN THE BŌSŌ PENINSULA. Sunao OGOSE. Many views have been published in respect to the boundary between Pliocene and Pleistocene, but recently a predominant view is that the Umegase sandstone and part of the alternation of sand and mud (including part of the Otashiro alternation of sand and mud) distinctly belonging to the Pleistocene. Thereupon, the writer investigated the changes of water temperature indicated by the fossil mollusks in each bed, from the Umegase sandstone and the alternation of sand and mud to the Yabu sand and gravel beds and the Hitomi alternation of sand and mud, both of which are regarded to belong to Pleistocene. As a result, it was disclosed that the water temperature in the shallow sea area was low in the period of deposition of -

(1) the Umegase sandstone and part of the Hitomi alternation of sand and mud (Hasumi sand beds),

(2) the Nagahama sand and gravel beds and part of the Matano sand and gravel beds,

(3) the uppermost post of the Kasamori mud beds and the Sunami alternation of sand and mud, and

(4) the Yabu sand and gravel beds and the Hitomi alternation of sand and mud. Paleogeographic and paleosedimentologic significance of the fall of sea water temperature in each period was discussed. In addition, a view of the relationship between this problem and the problem respecting the boundary between Pliocene and Pleistocene was published.

ON THE CLIMATE IN THE PALEOLITHIC AGE IN KOTSUKE PROVINCE. Fusao ARAI and 2 others. The middle part of the peat beds discovered in the vicinity of Nikkawa, Niisato-mura (168 m above sea level), Seta-gun, Gumma Prefecture, can be correlated with the first black zone (Iwajuku I culture containing bed) of the Jōshū loam. This was proved by comparison of heavy mineral constituents and by tracing a key pumice bed. The relationship between the Iwajuku I cultural period and the glacial period is described by inferring the environments at the time of sedimentation, during the Iwajuku I cultural period from the results of analyses of

pollen and diatoms in the peat.

(1) The dominant genera in pollen analyses are *Quercus* sp. and *Fagus* sp. The genera resemble the forest constitution of a deciduous broad-leaved forest zone between the 1,000m to 1,500m above sea level at present, and a climate averaging 6° to 7° C cooler than the present climate.

(2) In addition, Gramineae pollen, spores of ferns, and fresh water diatoms are abundant and the peat is considered to have been deposited in a humid low swamp or a shallow marsh.

(3) The first black zone is correlated with the bottom of the Tachikawa loam beds. Summarizing the above data, this period is considered to correspond at least with the subglacial stage (probably main Würm) of the Würm glacial period. Hence, the Iwajuku I culture is a culture controlled by this subglacial period.

SELECTED ABSTRACTS: LECTURES DELIVERED BY INDIVIDUALS

GEOLOGY AND OIL-BEARING STRUCTURE OF THE AREA SOUTH OF AOMORI CITY. Iwao KATŌ and 2 others. The Otakizawa anticline and the Magouchi-Aizawa anticline are noteworthy petroleum-bearing structures in the area south of Aomori City. The former is a closed structure with the Otakizawa beds as the core. The latter has not been known in detail due to the younger volcanic detritus (a part slightly welded) which extensively covers the area, but it is a folded structure passing into faults partly accompanied by diapiric upthrust intrusion. Moreover, the relation between the change of lithofacies in the direction of the extension of structure and the difference of phase of structural elevation is locally pointed out. The organic matter content (extracted amount) of the oil-bearing formation in this area is about 0.16 percent (30 gm material, solvent: 15 percent alcohol, 70 percent benzene, 15 percent acetone) in the black hard mudstones underlying the Ōtakizawa bed. This is oil facies almost similar to oil-bearing rocks in other areas. Hereafter the writer is to study the problem on the extension of the subsurface structure to the Goshogawara basin.

MICROBIOSTRATIGRAPHIC CORRELATION OF THE PRINCIPAL NEOGENE LOCALITIES IN WESTERN HONSHŪ. Yoshirō TAI. Based on volcano-stratigraphic data and the assemblage series of 13 stages induced by the changes of the composition of marine Neogene fossil Foraminifera distributed in Western Honshū, particularly in San'in and Setouchi regions, five stages were established. In ascending order they are:

- 1) the Tokari stage,
- 2) the Miوشي stage

3) Iwami-Ōta stage,

4) the Fujina stage, and

5) the lower Pliocene series which is not yet named.

The type of locality of each stage is as follows:

1) the Tsukiyoshi beds, the Tokari beds, and the Yamanouchi beds in the lower part of the Mizunami group in Mizunami City: this stage corresponds with the lower half of the Tokari stage established by J. MAKIYAMA.

2) The greater part of the Bihoku group in the Miyoshi basin, and the Uetsuki stage established by MAKIYAMA corresponds with a part of this stage.

3) The Kuri complex and Ōmori complex in the vicinity of Ōta City, Shimane Prefecture.

4) The Fushina complex on the south side of Lake Shinji.

5) The Matsue complex.

The Setouchi region includes 1), 2), and the lower part of 3), and the San'in region includes all the above stages except 1). The lower parts of 2) and 3) connect the above two regions. Considering the above facts, the horizon of the Tokari specimen of *Desmostylus* in Western Japan is in the lower part of 1), that of Fushina specimen is the middle part of 4), *Miogypsina* both from the Chūgoku district and the Nōbi district in the lower part of 2), and *Vicarya* from the Nōbi district is in the lower part of 1) and that from the Chūgoku district is in the lower part of 2).

ON THE GEOLOGY (PARTICULARLY IGNEOUS ROCKS) OF THE AREA NEAR ISHIZUCHI-YAMA, SHIKOKU. Kazue HORIKOSHI.

1. The igneous activity in the vicinity of Ishizuchi-yama is as follows:

(1) The Takano tuffs and the associated rhyolites,

(2) The Kuromori-tōge andesite and agglomerates (a. the Yoake-tōge rhombic pyroxene andesites, b. the Tengu-dake biotite-bearing--augite-hypersthene andesites),

(3) The Omogō acidic rocks [a. The Omogō granites (granite, diorite, etc.), b. the Aodaki-yama quartz porphyry, c. Trachytic andesites],

(4) the Saramine sanukitic andesites.

2. The Yoaketōge rhombic andesites contain tuff breccia, pitchstone, etc. They are considered to be important in the correlation of various areas on the Inland Sea.

3. The Omogō granites exerted metasomatism to the crystalline schists and andesites. Particularly the black Tengy-dake andesite was changed into grayish white andesitic porphyrite.

4. The magmatic evolution from the activity of tuffs to the intrusion of granites is a problem to be solved in the future.

FORAMINIFERA IN THE PALEOGENE FORMATIONS IN THE SOUTHERN PART OF THE SHIMABARA PENINSULA. Shigeo MURATA. Foraminifera in the Paleogene formations developed in the vicinity of Mukaigoya, Minami-arima-machi, Minamitakaki-gun and Yamaguchi, Katsusa-machi of the same county (-gun), Shimabara Peninsula, are characterized by Plectofrondicularia pseardi, P. packardi multilineatis, Bulimina sculptilis, B. schwageri, and Cassidulina globosa. Therefore, this formation corresponds to the Plectofrondicularia packardi zone of the upper part of the Sakasegawa group in Amakusa-shimojima, Kyūshū, and Horonai, Hokkaidō, and can be correlated with the Refugian (Oligocene) of the Gaviota formation on the west coast of North America.

Sedimentation and Bottom Deposits

ON THE CHARACTERISTICS OF SOME BORING SHELLS — PARTICULARLY ON THE TRACES OF TRAPEZIIDAE. Tsutomu UTASHIRO. This is a result of biological observation in the intertidal zone of the coast of Shiya, Kariha-gun, Niigata Prefecture.

(1) The writer found the traces of Trapeziidae together with those of Pholadidae. It is exceedingly difficult to distinguish them by the surface holes only, as shellfish belonging to Trapeziidae have a habit of reboring holes which were bored by Pholadidae.

(2) When the sections of holes bored by the two kinds of shellfish are compared, they can be distinguished easily. The section of a hole bored by Pholadidae becomes thicker and thicker with depth, and a concentric engraving remains at the bottom. On the contrary, in the section of a hole bored by Trapeziidae the form of the shell remains and a striking radial engraving is found on the inner wall.

(3) The inner wall of a hole bored by Pholadidae is smooth, but that of a hole bored by Trapeziidae is rough. This is the most important point when one is distinguished from the other.

(4) It is considered that the characteristic

ornamentation on the inner wall is due to the difference of boring method, that is, rotary mechanical action of Pholadidae and opening and shutting mechanical action of Trapeziidae.

A SEDIMENTOLOGICAL STUDY OF THE CONTINENTAL SHELF DEPOSITS (OFF YAMAGATA PREFECTURE). Hideo KAGAMI. Granularity and heavy mineral analyses of 117 samples of continental shelf deposits were attempted. This area is divided geomorphologically into two parts, with the Akashi Reef as the boundary. Deposits in the southern part are distributed in the following order: delta, littoral fine-grained sand zone, upper submarine step coarse-grained sand zone, and mud zone. In the northern part, the mud zone is distributed extensively next to the littoral fine-grained sand zone, and the continental shelf near Tobi-shima is composed of stagnant water deposits containing abundant chalcopyrite. The insular shelf deposits of Tobi-shima are characterized by shell fragment sand containing abundant decomposed minerals. The continental shelf deposits exhibit complicated features due to changes after deposition, but the deposition was made in the following order: the deposition in the bottom 110 m in depth which is shown by an extensive submarine flat plane and a submarine valley in the flat plane, the formation of a flat plane 60 m in depth and the deposition of coarse-grained sand, and shifting of fine-grained sand. After that, thick clay beds were deposited in the vicinity of Sakata, the gravel bed 40 m in depth was deposited, and mud was shifted from the upper submarine step in the south. Lastly, the deposition of littoral fine-grained sand and the formation of a delta occurred. The deposits on the upper submarine step are characterized by hypersthene which is considered to have been derived from Chōkai-san and Gas-san volcanos, and the littoral fine-grained sand is characterized by titanite considered to have originated from the Atsumi dolerite and others.

ON THE SUBMARINE RELIEF AND DEPOSITS OF KAGOSHIMA BAY. Michihiro HOSHINO and 4 others. The mouth of Kagoshima Bay is 100 m deep and the central part is about 200 m deep. It is a bay which becomes abruptly deep. However, as the sea water circulates rather well in this bay, the greater part of the deposits in the central part of the bay are in an oxidized condition and only the muddy substance in the deepest part northeast of Sakura-jima assumes a black color. The heavy mineral content is different in the parts north and south of Sakura-jima and the mouth of the bay. Heavy minerals are most abundant in the mouth of the bay and are next most abundant in the head of the bay.

Remains of as many as 297 species of Mollusca were distinguished; that is, 166 species of Pelecypoda, 125 species of Scaphopoda, and

three species of Pteropoda. As regards living Foraminifera, this bay is characterized by the distribution of pelagic species as far as the innermost part of the bay. *Bulimina marginata* is most predominant. Diatoms are very abundant and deposits which may be called diatomaceous ooze occupy the greater part of the bottom. The abundance of diatoms is due to nutritive salts which originated from volcanic activity, and the productivity of Foraminifera and Mollusca is based on the abundance of diatom.

FORAMINIFERA AND DEPOSITS OF THE ANTARCTIC SEA OBTAINED WITH PLANKTON NETS. Takayasu UCHIO. The deposits collected at 10 points (350 m - 2,480 m deep) during the first Antarctic expedition contains large and small moraines and glauconite was found in the deposits at 8 points. This shows that sedimentation does not occur very actively at present in the vicinity of Lütsholm Bay, particularly in the Gunnels Bank [T.N.; spelling not sure]. Foraminifera remains in the deposits are classified into three assemblages, that is, *Angulogerina angulosa*-*Ehrenbergina glabra*; *Bulimina aculeata*, *Epistominella exigua*, and the boundaries of the assemblages are at a depth of about 850 m and 2,000 m. The first and third assemblages represent the circum-Antarctica water (?) and the bottom layer water of Antarctica respectively. The second assemblage may represent the uppermost part of the bottom layer water. About 87 percent of the Foraminifera tests in the deposits are *Globigerina pachyderma* (including "*G. dutertrei*"), but *G. cf. bulloides* was obtained with a planktonnet (at 2 points). This may be due to having towed a planktonnet in the surface water in summer or *G. pachyderma* may not be plankton. Living shells of this species have not yet been found, so it is unknown whether it is plankton or not. If the species is plankton, its extensive distribution was deposited in the glacial age, and, together with glauconite, may suggest that deposition hardly occurs in this area at present.

ON THE CAUSE OF THE PECULIAR DISTRIBUTION OF THE $\alpha\phi$ VALUES (GRANULARITY DISTRIBUTION) IN A GROUP OF DEPOSITS.

Noriyuko NASU. Scores of the samples were collected of littoral deposits of Sagami Bay and deposits of the Obitsu-gawa and the Yōrō-gawa deltas in Tokyo Bay. Granularity analysis of these samples was carried out and the results were analyzed by means of Inman's $Md\phi - \alpha\phi - \alpha\phi$ system. In this case a peculiar distribution common to $Md\phi - \alpha\phi$ was noticed. That is, the $\alpha\phi$ value is rather markedly negative within the extent where $Md\phi$ ranges from medium-grained sand to fine-grained sand, but the value abruptly becomes very large within the extent where $Md\phi$ ranges from very fine-grained sand to very coarse silt. After that, the $\alpha\phi$ value decreases again as the $Md\phi$ value turns from

silt to clay and returns to 0 or so. This abrupt change of the $\alpha\phi$ value at the time when the $Md\phi$ value shifts from fine-grained sand to very coarse silt can be explained by a universal principle on hydrodynamics -- a general principle that each sandy substance and each muddy substance are separated by combination of changes of the features of settling velocity and velocity of initial motion due to the difference of the diameter of grains. When the muddy substance is separated from a sandy and muddy substance, the $\alpha\phi$ value become negative, and when the sandy substance is separated, the $\alpha\phi$ value of silt becomes positive.

ON THE FLOW VELOCITY IN THE GORGE OF THE AZUSA RIVER. Masahiko ŌYA. Hitherto it has been considered that, generally speaking, the flow velocity is larger in mountainlands and gorges where the gradient is steep and the water is deep as compared with shallow basins where the gradient is gentle and the water is shallow. However, as was already published, the flow velocity obtained by surface floats which were allowed to flow for a long distance in the mountainlands, basins, and gorges of the Sarugaishi River and the Chikuma River was smaller in the mountainlands and gorges and larger in the basins without exception. This time, for the purpose of confirming the above-mentioned phenomenon by means of a method different from floats, a saline solution and a pigment (malachite green) were allowed to flow for 100 to 470 meters, the electric conductivity and resistance were measured by means of precise instruments, and thus the flow velocity was obtained in the mountainland, basin, and gorge of the Azusa River. The results were the same as the results obtained by means of floats, that is, the flow velocity is smaller in the mountainland and gorges and larger in the basin. It is considered that this phenomenon is caused by larger resistance against the flow in the mountainland and gorge due to detritus supplied from both banks and the river floor and the strikingly uneven basement of the river floor.

Ore Deposits, Minerals and Metamorphic Rocks

THE NIKYO GABBROS AND NICKEL-BEARING PYRRHOTITE DEPOSITS IN THE OKUSHIBETSU DISTRICT, HIDAKA ZONE. Kitsusuke KANA-YAMA. This area has been considered the northern facies of the Hidaka metamorphic zone. The change of plutonic rocks from olivine gabbro to tonalitic rock is closely related to structural movements and metasomatism. As regards the changes of lithofacies, each rock is changed into a more basic one and is oxidized in the course from the early facies to the late facies. In these rocks porphyroblasts of plagioclase are produced in the early facies, are changed into coarse grains, and are replaced. The ore deposits

correspond with the second stage of plutonic action in this area, and the ore deposits are considered to have been formed as a forerunner to metasomatism. The alteration of country rocks of the ore deposits is remarkable, and the increase of An content and the migration of Mg and Fe contents of olivine and rhombic pyroxene are noticed. Porphyroblasts of plagioclase are produced and oxidized; moreover quartz is involved. The change of constituents in the plutonic rocks and the pattern of alteration in the formation of ore deposits resemble each other. The cause of this resemblance is unknown.

ON THE KANINOMATA ORE DEPOSITS IN THE ŌBORI MINE, YAMAGATA PREFECTURE. Hisamitsu HARADA and 7 others. In recent years, deposits of a special type have been discovered in the hydrothermal ore deposits distributed in the green tuff area in the inner zone of northeast Japan. The Kaninomata ore deposits for one example.

This mine is composed of skarn-bearing copper, zinc, bedded deposits of lead (Kaninomata ore deposits), and epidote, calcite, quartz, copper, and zinc veins (Nakanomata ore deposits), which occur in the Miocene series (Kaninomata beds, Kumano-kaeri beds), of Neogene. The bedded ore deposits are skarn which was developed by replacing calcareous tuff and brecciated tuff beds and was replaced selectively. Many fine veins of copper, zinc, and epidote which traverse the skarn-bearing bedded ore deposits are found in the ore shoots. The skarn minerals are epidote, wollastonite, grossularite, bastamite, and calcite. The ore minerals are chalcopryrite, zinblendite, galena, and wittichenite(?). From these respects, the ore deposits are considered to be metasomatic deposits of a new type in the green tuff area.

EXPERIMENTAL STUDIES ON THE MAGNETIC PROPERTY AND CRYSTAL STRUCTURE OF Fe-Mn OXIDE. Hajime YIN. In Mn-ferrite which is composed of Mn_3O_4 and Fe_3O_4 the curie point rises gradually with an increase of the chemical constituent of Fe_3O_4 , and becomes $575^\circ C$ when Fe_3O_4 is 100 percent. As to the strength of magnetism, it is the maximum when the ratio of Mn_3O_4/Fe_3O_4 is 16.7 percent, and the value is about 1.5 times of the value of magnetite (140 c. g. s. emu/gm). Before and after this maximum value the strength of magnetism tends to decrease. It was disclosed by means of X-ray analysis that in Mn-ferrite, $\begin{smallmatrix} 103, \\ 224, \end{smallmatrix} \begin{smallmatrix} 211, \\ 400 \end{smallmatrix}$ of the tetragonal phase converges gradually into $\begin{smallmatrix} 311, \\ 440 \end{smallmatrix}$ of the cubic phase by an increase of the chemical constituent Fe_3O_4 , and when Mn_3O_4/Fe_3O_4 becomes more than 60 percent, it migrates perfectly into a cubic type. Based

on a series of experiments, Meson's definition (54 - 16.7 percent Mn_3O_4) on jacobsite which is Mn-ferrite was extended, that is, the definition was extended from Mn_3O_4/Fe_3O_4 60 percent to a position just before magnetite, and Mn-ferrite belonging to tetragonal type was named provisionally mangano-jacobsite.

From the results of experiments carried out on more than 50 samples of native Mn-ferrite, it seems that in nature ferrite of C. P. $160^\circ C$, that is, Mn_3O_4/Fe_3O_4 60 percent is abundant, and jacobsite belonging to the cubic type is more abundant than mangano-jacobsite.

THE RELATION BETWEEN THE CHARACTER AND THE MODE OF OCCURRENCE (ORIGIN) OF CHLORITE. Haruo SHIRAMIZU. About 50 kinds of chlorite from Japan, having relatively high crystallinity, were studied from the mineralogical point of view and were arranged according to the mode of occurrence. The results show that:

- 1) In epithermal veins, Fe substances, the X-ray powder pattern of which is orthohexahedral, and for Fe and Mg substances, the X-ray powder pattern of which is monoclinic, are found together. The orthohexahedral type which are crystallized from solution and the type which replaced fragments of country rock are structurally different from each other.
- 2) The monoclinic type which abounds in Mg than (1) occurs in the mesothermal veins.
- 3) The monoclinic type which abounds in Mg occurs in skarn.
- 4) Monoclinic Mg and Fe substances are found in cupriferous iron sulfide deposits and crystalline schists, and the former contains more Fe than the latter.

5) Serpentine is associated with monoclinic Mg substance containing a certain amount of Fe.

6) Chlorite from manganese deposits exhibits various characters. This may be due to various origins. Chlorite of relatively high crystallinity is almost ideal in chemical composition, the Al content is relatively constant, and it is considered a product of the most favorable conditions for the formation of chlorite.

ON THE RESULT OF EXPERIMENTS ON SOME HYDROTHERMAL COMPOSITION (1,000 Atm.) RELATED TO THE DISCLOSURE OF THE PARAGENESIS OF CLAY AND ZEOLITE. Mitsue KOIZUMI. Recently the occurrence of zeolite-bearing bentonite has been reported from various places of Japan in succession, and it has been recognized that, not only argillization, but also zeolitization must be considered to be important in the alteration process of tuff.

For the purpose of disclosing an alteration process like this a hydrothermal experiment may be an effective method, and the result of the writer's experiment on the composition and its stability of clay minerals of $\text{Na}_2\text{O}-\text{Al}_2\text{O}_3-\text{SiO}_2-\text{H}_2\text{O}$ series and $\text{CaO}-\text{Al}_2\text{O}_3-\text{SiO}_2-\text{H}_2\text{O}$ series and zeolite suggests that the following elements are a part of the conditions promoting the formation of the two minerals. (1) Chemical composition of the parental substance, (2) existence of CO_2 in solution (if CO_2 is added to the above-mentioned series, the formation of Montmorillonite minerals is promoted), etc. The results obtained by the writer are in a preliminary stage. At present experiments on hydrothermal alteration of zeolite-bearing bentonite and further detailed studies on the paragenesis of zeolite and clay are in progress.

METAMORPHIC ROCKS IN THE TANZAWA MOUNTAINLAND -- PARTICULARLY THOSE IN THE NORTHERN PART. Yoshimasa KURODA and 3 others. It has been believed that the metamorphic rocks which gradually reached the hornblende facies from the Misaka beds occur around quartz diorite. However, the metamorphic rocks are not always found around the quartz diorite. In the western part the metamorphic rocks are fairly widespread, but in the eastern part they hardly occur. Moreover, the structure of the metamorphic rocks takes a north-western direction. Even if the schistosity takes an east-to-west direction, almost all of the linear structure dips northwestward. This is the same for metamorphic rocks on both the southern and northern sides. The metamorphic rocks in the northern side have undergone striking metasomatism, particularly exhibited by biotitization and cordieritization. The migration and differentiation of K, Al, Mg, and Fe are remarkable. An interesting relation between metamorphic differentiation -- metasomatism and the metasomatic degree (P-T) is suggested.

The quartz diorite also is very peculiar and the characteristics of the basic rocks are remarkable as a whole. A detailed paper is to be published in the near future.

METAMORPHIC ROCKS OF THE TSUKUBA AREA. Tatsujirō UNO. The metamorphic rocks exposed about 6 km wide in the area south-east of Tsukuba-san are divided into four zones representing the degree of the progressive metamorphism according to the formation and disappearance of minerals in pelitic rocks. Zone I is characterized by the lack of andalusite, Zone II by the combination of andalusite and muscovite, Zone III by the combination of sillimanite and muscovite, and Zone IV by the combination of sillimanite and K-feldspar. Metamorphism has progressed toward the northwest.

Five samples averaged from those collected

from Zone I to Zone III of the pelitic rocks distributed in this area were analyzed chemically. The results revealed that there was almost no change in the chemical composition accompanying the progress of metamorphism, and only a slight difference of the amount of Fe^{+2} , Mg, K, and Na was noticed in some zones. Therefore, it cannot be considered that gneiss distributed in an extensive area is produced by lit-par-lit injection of aplitic material as considered by SUGI (1930).

ON THE METAMORPHIC ZONING IN THE SAMBAGAWA CRYSTALLINE SCHIST AREA IN THE VICINITY OF SHIBUKAWA, SHIZUOKA PREFECTURE. Mizuo AIRA and 2 others. The Sambagawa metamorphic rocks are distributed fairly extensively in the area north of Hamamatsu, and can be divided into the following mineral zones according to the various combinations of several metamorphosed minerals.

Zone I (Zone IA - Epidote-pumpellyite-glaucophane subfacies). Zone IB - Epidote-pumpellyite-lawsonite-glaucophane subfacies),

Zone II - (Epidote-glaucophane subfacies),

Zone III - (Epidote-sodic hornblende subfacies).

The grades of metamorphism and recrystallization are considered to have progressed in the order of Zone I, Zone II, and Zone III. Zone III is considered to correspond with the degree of metamorphism which is locally high due to the intrusion of basic igneous rock. These subfacies are distinguished from the common green schist facies and the epidote-hornblende facies by the occurrence of glaucophane, pumpellyite, lawsonite, and sodic hornblende (edenite). The writers discovered jadeite from Zone IB. The occurrence of jadeite must be an important evidence that the Sambagawa metamorphic zone was formed under high pressure.

CHARACTER OF METAMORPHISM AND CHEMICAL COMPOSITION OF BIOTITES. Fumiko SHITŌ. In metamorphic rocks which originated from sandstone and pelitic rocks, pyralpsite garnet is a ferromagnesian mineral which coexists with biotite. It is known also by the distribution of $\text{Mg} + \text{Fe}^{+2}$ that pyralpsite is a mineral which likes Fe better than does biotite. Cordierite which coexists with biotite frequently is a mineral which is more fond of Mg than is biotite. The greater the solid phase pressure at the time of metamorphism, the more pyralpsite is liable to appear. On the contrary, the lower the solid phase pressure at the time of metamorphism, the less cordierite is liable to appear. Consequently it is expected that biotites which were formed under the less solid phase pressure generally are higher in the ratio of $\text{Fe}^{+2}/(\text{Mg} + \text{Fe}^{+2})$ than biotites formed under the more solid

phase pressure. The position and maximum of the index of refraction frequency curve of biotites from the metamorphic zone characterized by the occurrence of kyanite and jadeite + quartz approach the lower index of refraction as compared with biotites from the metamorphic zone characterized by the formation of andalusite. By this it is confirmed that the above hypothesis is probably correct.

Volcanic Rocks and Volcanic Activity

PRELIMINARY REPORT ON THE MAGNETIC SURVEY OF KABUTO-YAMA, HYŌGO PREFECTURE. Eigo KŌ. The magnetic anomaly of about $\pm 1,000 \gamma$ was observed in both vertical and horizontal components. This value was beyond expectation, but as a result of remnant magnetism measurement of rock materials it was revealed that this is a reasonable anomaly. The remnant magnetism of the rock materials shows much larger value than that of common volcanic rocks. Moreover, it is noteworthy that the direction of remnant magnetism of the materials collected in the southern slope of the mountain corresponds with the direction of magnetic field of the earth, while that of the materials collected in the northern slope does not. The tendency seems to be the same in the same in the intensity of remnant magnetism. In a graph showing magnetic anomaly section, a saddle of the magnetic force lines corresponds with the summit of the mountain. In short, when it is assumed that the rock mass of Kabuto-yama is homogeneous, it is necessary to consider a topographic saddle at the summit, and when, as shown by the result of remnant magnetism measure, a lack of magnetic uniformity is considered, the petrological heteropic facies and the stages of effusion may come into question.

ON THE SHIGA WELDED TUFF. Nakao IJIMA. The Shiga welded tuff which hitherto has been regarded to have been effused from the so-called Arafune volcano lying in the border between Kōzuke and Shinano Provinces is divided into (1) the Hongō type, Mt. Acal type [T.N.; spelling not sure], and (2) the Yasuhara type, which are the effusives of the volcanic activities of two different systems. The former was not the effusive from Arafune volcano, but the former's center of activity was the green tuff area in the northwestern part. The latter was emitted here and there in the non-green-tuff area. In the former, the effusion occurred in the following order: hypersthene porphyryite, hypersthene hornblende andesite, hypersthene andesitic Hongō type, and Mt. Acal type. However, the latter was emitted next to basalt and basaltic andesite. It is unknown whether or not welded tuffs of different systems of volcanic activity reflect the difference of the geology of the basement. The Hongō and Yasuhara types are fairly rich in alumina; however,

and consequently corundum occurs as a norm mineral. This may be an effect of contamination. The alkalic content is almost equal in each type, but the Yasuhara type is poor in lime. As regards norm feldspar, the Yasuhara type is rich in Ab- Δ as compared with the Hongō type.

SOME PETROLOGICAL NOTES ON THE WELDED TUFFS IN THE TŌHOKU DISTRICT. Katsutoshi TANIDA. In respect to the Plio-Pleistocene welded tuffs distributed along the backbone range of the Tōhoku district, it was revealed from newly-made analysis and already-published data that the SiO_2 content is 64 to 75 percent and the chemical constituents are common to those of the lavas of the Nasu volcanic zone. Moreover, the alkali-lime index is 65.0 and this value shows that the welded tuffs are highly calcic.

In most of these welded tuffs devitrification of matrix has progressed remarkably parallel to welding. There are still many unsolved questions, on devitrification products and the conditions under which they are produced. The writer succeeded in extracting spherulite, which is one of devitrification products, and its X-ray study was made. The result disclosed that the constituent minerals are cristobalite, tridymite, sanidine, and anorthoclase. Based on these results, the conditions in the course of the growth of spherulite in the welded tuffs are briefly described.

ULTRABASIC INCLUSIONS IN THE BASALTIC ROCKS OF SOUTHWESTERN JAPAN. Katsu YAMAGUCHI. Of the basaltic rocks of Southwestern Japan, the alkali olivine basalt or limburgite in Dōgo in the Oki Islands, the areas around Tsuyama City, Nochi in Okayama Prefecture, Oguso-yama in Shimane Prefecture, and Karatsu and Emukai in Saga Prefecture include various ultrabasic rocks. The petrographic types of the inclusions are dunite, peridotite, two-pyroxenite, gabbro, etc. The distribution of each type more or less differs in each area. The inclusions are of various shapes. Some of them are brecciated.

The constituent minerals are olivine, Cr-diopside - diopside, aluminous augite, enstatite-hypersthene, picotite, etc. These minerals have a character which is not related to the basaltic rocks. That is, the olivine exhibits a zonal structure due to the effect of stress. The pyroxene without exception has marked exsolution lamellae. X-ray analysis of a single crystal reveals that some aluminous augites are separated into clino-pyroxenes of three or four facies. From these facts, it is beyond doubt that the inclusions are xenoliths, and it is reasonable to consider that the inclusions originated from an ultrabasic intrusive rock mass which was produced in the deep part of the crust and underwent considerable stress.

STUDIES ON THE ROCK MAGNETISM OF PLIOCENE VOLCANIC ROCKS AROUND LAKE SUWA. Kunio KOBAYASHI and 2 others. A pyroclastic rock bed (Shiomiine complex) consisting of tuff-breccia and a small quantity of lava (called Teppei-seki or Hiraishi) is found around Lake Suwa. This lava shows the inversion of the earth's magnetic field and indicates that it is of late Pliocene. The age of effusion of scattered lavas can be correlated from the changes of the magnetic field of the earth in the Central Japan since the end of the Pliocene as disclosed by MOMOSE. It is also reasonable from the viewpoint of volcano-stratigraphy.

The lavas mainly consist of two-pyroxene andesite and are accompanied by olivine-bearing two-pyroxene andesite, hornblende-bearing two-pyroxene andesite, and hornblende andesite in the uppermost part. Each lava is thin-spread and extensive. The so-called Kirigamine aspite is a member of the Shiomiine complex and does not overlie the Shiomiine complex. The present study broke fresh ground in the application of rock magnetism to volcano-geology.

Mesozoic

GEOLOGY OF THE AREA AROUND THE RYŌSEKI BASIN. Kunihiro ISHIZAKI and Kazumi SUYARI. The relation between the Paleozoic group and the Cretaceous system has been considered a para-unconformity and no structural difference was believed to exist between the two. Quite recently, however, data which shake the above explanation were reported from various places, and in connection with it the period of movement in the Chichibu complex has been questioned.

For the purpose of studying the above problem, the writers examined the basement of this area. The results revealed that the Paleozoic group generally strikes EW - ENE - WSW and exhibits a gentle basin structure. It was also disclosed that the Cretaceous system indicates a strike along the curve in the western margin of the Ryōseki basin. The Paleozoic group and the Cretaceous system are considered to lie in almost initial unconformity, and no remarkable faults seem to be found. Therefore, there must be a remarkable structural difference between the above two formations. This relation is probably not a parallel unconformity but an oblique unconformity.

THE UPPER CRETACEOUS SYSTEM IN THE DRAINAGE BASINS OF THE TERIO AND ABESHINAI RIVERS. Kōji TAKAHASHI. The Cretaceous system in the area studied by the writer is divided in ascending order into the middle Ezo group and the upper Ezo group. The former is subdivided into the Sakugawa beds and the Saku beds, and the latter into the Nishichirashinai beds, the Omagari beds, and the Ososhinai beds. The Saku beds and the Omagari beds exhibit a sandstone facies and the

Ososhinai beds are divided into five layers. The Yasukawa group which formerly was called the Hakobuchi group and mainly consists of sandstones overlies unconformably the Ososhinai beds. The Yasukawa group is divided into five layers.

The writer has no objection to the correlation of the Ezo group based on fossils. The Yasukawa group yields only Metaplacenticerias substriatum (JIMBŌ), so it is impossible to correlate it with the Ishikari coalfield area. However, judging from the correlation based on the sedimentary cycle, the Yasukawa group may correspond with the early Hetonnai epoch.

Paleozoic

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION OF THE FOSSIL CALCAREOUS ALGAE FROM THE UPPER PALEOZOIC OF JAPAN. Ryūji ENDŌ. In Japan Rhodophyceae has been known from only the Artinskian up to the present. Mizzia has been reported from only the Artinskian-Kungurian. M. velebitana is distributed extensively, so it is an appropriate index fossil. Calcareous algae which are known mainly from the Triassic in Europe, such as Macroporella, Gyroporella, Diplopora, Teutloporella, Oligoporella, and Physoporella are discovered frequently from the Permian in Japan. Clavaphysoporella occurs in the upper and middle Permian alone. Drinella is the index fossil of the Moscovian, and Koninchopora and Anatoripora are the index fossils of the Viséan. Five species of Gymnocodium have been reported up to the present, and it is noteworthy that all of them are found from the Kungurian. Three species of Anchicodium have been known, and they are distributed extensively. They are found without exception from the Sakmarian. Up to the present noteworthy division of geographic distribution has not been found. They are almost the same in such areas.

ON THE UNCONFORMITY FOUND IN THE CARBONIFEROUS ICHINOTANI FORMATION. Hisayoshi IGO. The Ichinotani formation has been treated as a conformable and continuous series of sediments. However, the writer confirmed an unconformity between the Profusulinella zone and the Fusulinella zone. The lower part of the latter begins with chert breccia which is due to the solution of limestone; it is overlain by an alternation of red shale and gray- and chocolate-colored shale. This shale consists mainly of quartz and kaolinite. It was confirmed by X-ray examination that the red shale contains hematite and other shale contains siderite. Chemical analysis disclosed that this shale is rich in Al_2O_3 and very poor in K_2O and Na_2O . The red shale is rich in Fe_2O_3 and the gray- and chocolate-colored shales are rich in FeO . These shales are considered to be sediments in the environments in which the pH value is constantly less than 7 and the changes of oxidation-reduc-

tion potential were remarkable; that is, the sediments were deposited in fresh water. From this conclusion the writer maintains that the Ichinotani beds are not a geosyncline type but are sediments of marine and fresh water facies, and are in other words, continental type sediments like those of South Manchuria and North China. In addition, the climate in that age is considered to have been hot and humid and sediments were easily lateritized. Furthermore, it is easily explained by the present study that the Ichinotani beds are very thin.

ON THE MODE OF OCCURRENCE AND GENESIS OF THE CHERT DEVELOPED IN THE PALEOZOIC GROUP IN THE SOUTHERN PART OF THE TAMBA AREA. Shigeo SAKAGUCHI. In the Paleozoic of the southern part of the Tamba area chert is remarkably developed. The chert does not continue in a bedded form but is like an irregularly shaped yam. The yam-like chert consists of massive or seam chert. The seam chert generally has undergone some small folding. Judging from the mode of this folding, it is beyond question that the chert underwent the folding movement when it was not solidified, immediately after deposition. The chert is developed best in the black shale. The chert also is closely related to the schalstein and is distributed in the sandstone. The lower part of the strata containing chert in this area mainly consists of chert, schalstein, and shale; in the upper part these rocks decrease and sandstone increases, and in the uppermost part chert and schalstein are not developed. The chert in this area is considered to be of syngenetic origin from its shape, size, and the relation to its original rock. The chert is considered also to have been deposited in a relatively deep sea, that is, in the central part of the geosyncline.

ON THE CARBONIFEROUS FOSSIL CORAL FAUNA IN THE INNER ZONE OF SOUTHWESTERN JAPAN. Makoto KATŌ. There are two types of species of Carboniferous corals in the inner zone of southwestern Japan. One represents the Fukuchi area and continues from the Onimaru-Kamitsuka type including the genera of *Heterocaninia*, *Paleosmia*, *Dibunophyllum*, and *Siphonodendron* to the Nagaiwa-Mototani type including the genera of "*Cystophora*" and *Arachnastraea*. The other is the Nagatophyllum fauna, which is shown in the fossil fauna of the Akiyoshi area. This fauna belongs to the so-called *Amygdalophyllum*-*Kionophyllum* type fauna consisting of the genera of "*Clisaxophyllum*", *Nagatophyllum*, *Amygdalophyllum*, *Akiyosiphyllum*, *Echigophyllum*, *Lonsdaleoides*, "*Stylidophyllum*", *Lithostrotionella*, *Taisyakophyllum*, *Amygdalophylloides*, *Pseudopavona*, etc., and is extensive in the limestone in the Omi, Atetsu, Oga, Taishaku, and Skiyoshi areas in the Inner Zone of South-

western Japan. The period of beginning of the *Nagatophyllum* fauna, is not distinctly known, but the principal part corresponds to the *Millerella* zone - *Profusulinella* zone of the lower Pennsylvania system. A part of the element of the fauna extends to the *Fusulinella* zone.

STRATIGRAPHY OF THE GOTLANDIAN FORMATIONS IN THE OUTER ZONE OF SOUTHWESTERN JAPAN. Ryūshi HAMADA. The writer succeeded in determination of the zones and age of the Gotlandian formations in various places in the outer zone by *Halysites*, *Tetracoralla*, *Trilobitae*, *Brachiopoda*, etc. G_2 is determined as Upper Wenlockian on the basis of *Falsicatenipora shikokuensis*, and *Coronocephalus kobayashi* and G_3 determined as Low. Ludlovian on the basis of *Schedohalysites kitakamiensis*, *Conchidium* cf. *knighi*, and *Zolophyllum* sp. G_4 is a coarse thick layer which is rich in granitic clastic material and accompanied by acidic volcanics. Inferred from the volcanic activity in the lower half of the Ono and Nakasato in the Kitakami district, the upper limit of G_4 may reach Low. Couvinian. Judging from the distribution of *Favosites hidensis* of the Devonian type, the greater part of the "Gotlandian formation" described by Fukuchi may be Lower Devonian. In this layer acidic volcanic materials are also found. By these igneous and volcanic activities it has become more possible that the age of "Oboke sandstone schist" is considered Up. Got. - Low. Dev. In addition, the petrologic constitution and migration of the reef limestone facies from the Outer Zone of the Inner Zone support the inference that there were gentle crustal movements corresponding to the Kuang-hsi movements in Lower Devonian.

Quaternary

POLLEN ANALYSIS OF THE QUATERNARY SEDIMENTS IN THE VICINITY OF TOKYO AND YOKOHAMA. Misaburō SHIMAKURA. In the silty, fine-sand, and humic Quaternary sediments distributed in the vicinity of Tokyo and Yokohama, many contain fossil pollen and spores. The result of pollen analysis of these sediments will be described. The Naganuma beds are rich in pollen of *Pinus-Tsuga-Cryptomeria*. On the other hand, the Naganuma beds contain pollen of *Dicotyledoneae* of various kinds and those characteristic of a cold climate are not found. In the Hodogaya gravel beds pollen of *Pinus-Tsuga-Larix* are found plentifully. The beds hardly contain any pollen of *Dicotyledoneae*, and are of the boreal type. In Ikonji in the vicinity of Hachiōji a similar bed is found. Of many materials obtained in course of construction work in Tokyo, the materials from the Tokyo beds contain pollens of trees and herbs of various kinds and some of the materials are rich in *Abies-Cryptomeria*, some in

Pinus, and some in Alnus-Compositae. The materials from Egota are not simple. Besides the so-called Egota Conifer-bed type which is rich in Larix-Tsuga, there is a type which is

rich in Abies-Alnus and there is also a type containing Styrax. In the Byōbugaura beds and the Shimosueyoshi beds there are pollen floras of various types.

Reference Section

RUSSIAN AND EAST EUROPEAN GEOLOGIC ACCESSIONS OF THE LIBRARY OF CONGRESS

This section is devoted to a listing of selected geologic items appearing in the two publications of the Library of Congress; Monthly Index of Russian Accessions, and East European Accessions Index. These lists are intended as a means of indicating to researchers in the earth sciences some of the material most recently available for screening, further review, and translation. For this reason the lists do not include material now, or soon to be, published in English. Emphasis is placed on Russian material; the extent to which items from East European sources are listed depends on the country and language involved.

A major function of the AGI translations program is the screening of foreign literature for material that should be made available to the English-speaking scientist. Researchers who need such material are urged to review these lists and send us their recommendations for consideration by the editors; the translation needs of all geologists will be served better thereby.

-- Managing Editor

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BUDAPEST. VIZGAZDALKODASI TUDOMANYOS KUTATO INTEZET. Magyarorszag vizkeszlete. Budapest. [Water resources of Hungary. fold. maps (part col. in pocket), bibl., diagrs., footnotes, graphs, tables]
Vol. 3. [Water storage possibilities]
Pt. 1. [Text] 1958. 477 p.
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REFERENCE SECTION

Recurrent features: Letter box; News of the Society.

Vol. 93 [i.e. 15] no. 9, Sept. 1960.

Balla, B. Possibilities of producing cryolite and aluminum fluoride in Hungary. p. 415.

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12. GEOGRAPHY & GEOLOGY

CHURSKI, ZYGMUNT. Jezioro Mukrz i jego okolice pod wzgledem hydrograficznym i geomorfologicznym. The hydrographic and geomorphological aspects of Lake Mukrz and its surroundings. Torun, 1953. 12 p. (Towarzystwo naukowe w Toruniu. Studia. Supplementum, 5, nr. 1) [English summary. maps (1 fold.)]
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PRUFFER, JAN, ed. Z badan zespolowych wydmy Zdroze pod Toruniem. Collective investigations concerning the Zdroze dune near Torun. Torun, 1949. 87 p. (Towarzystwo Naukowe w Toruniu. Studia. Supplementum, 1) [English summary. diagrams., maps (part fold.)]
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Recurrent features: Bibliography; Book reviews.

Vol. 20, no. 8, Aug. 1960.

Skibniewski, L. Anomalies of the water flow of the Oder River. p. 348.

Cebulak, K. Water balance of the low situated areas. p. 351.

Fanti, K. Some remarks on the coefficient of the loss of the overflow with a well-rounded crown. p. 354.

Liwski, S. Microelements; manganese, iron, boron, copper, cobalt, zinc, and molybdenum in meadow and swamp plants. p. 383.

PRZEGLED GORNICZY. (Stowarzyszenie Naukowo-Techniczne Inzynierow i Technikow Gornictwa) Katowice. [Issued by the Scientific-Technical Association of Mining Engineers and Technicians. Includes supplements: Biuletyn Głównego Instytutu Gornictwa, bulletin of the Central Institute of Mining; Biuletyn Instytutu Mechanizacji Gornictwa, bulletin of the Institute of Mechanization in Mining; and Przegląd Dokumentacyjny Gornictwa, documentation. Monthly]
Recurrent features: Current news; Foreign review; Polish standards.

Vol. 16, no. 9, Sept. 1960.

Woyciechowski, J. The choice of a method of rock-salt mining. p. 459.

Badak, J.; Pawlowski, R. Possibilities of quarrying road stone between the Vistula River and Ustron. p. 461.

Wanat, J. An analysis of accidents caused by the falling of rock masses. p. 464.

Maneck, A.; Młodożeniec, W. Up-to-date results of the examinations of the polymetallic layouts in Stara Gora. p. 380.

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Vol. 5, no. 9, Sept. 1960.

Gabrys, J. Exploitation of supporting ore pillars applying concrete stowing in the Marchlewski zinc and lead ore mines in Beuthen. Pt. 1. p. 358.

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Academia Republicii Populare Romine. Institutul de Geologie si Geografie. STUDII SI CERCETARI DE GEOLOGIE. Bucuresti. [Journal on geology issued by the Institute of Geology and Geography, Rumanian Academy; with French and Russian summaries. Superseeded in part, in 1958, and continues the vol. numbering of Academia Republicii Populare Romine. Buletin stiintific, Sectia de geologie si geografie, which superseeded in part, in 1956, Academia Republicii Populare Romine. Sectiunea de Stiinte Biologice, Agronomie, Geologie si Geografice. Buletin stiintific, issued before 1951 as Academia Republicii Populare Romine. Buletin stiintific. Seria: Geologie, geografie, biologie, stiinte tehnice si agricole. See also Academia Republicii Populare Romine. Buletin stiintific. Sectia de biologie si stiinte agricole. Seria agronomie, Academia Republicii Populare Romine. Studii si cercetari de biologie. Seria biologie animala, and Academia Republicii Populare Romine. Studii si cercetari de biologie. Seria biologie vegetala. Quarterly]

Vol. 5, no. 1, 1960.

Raileanu, G.; Nastaseanu, A. Contributions to the knowledge of the Ammonite fauna of the Superior Jurassic in Svinita, Banat. p. 7.

Chiriac, M. New Tortonian appearances in southern Dobruja. p. 39.

Liteanu, E.; Schoverth, E. Observations on the genus *Horodiaca* Sabba. p. 63.

Pauca, M.; Patruilus, D. Contributions to the paleontologic study of Albian deposits in Giurgiu, Danube Valley. p. 85.

Contributions to the study of Senonian Hippurites in the Hasdate, Stolna region, Iara basin, Apuseni Mountains. p. 101.

Vilceanu, P. Contributions to the geologic knowledge of the Codlea region. p. 119.

Papiu, V. On the origin of the mineralization of thermal waters in Baile Herculane. p. 135.

Szoke, A. Study on plagioclase in the subvolcanic massif of Torolaga, Baia-Borsa. p. 149.

Airinei, S. Normal and inverse magnetizations in the region of the andesite volcano Uroiu, Hunedoara region. p. 169.

Visarion, M.; Andrei, J. New geophysical data on the central zone of the Hateg depression. p. 197.

REVUE DE GEOLOGIE ET DE GEOGRAPHIE. JOURNAL OF GEOLOGY AND GEOGRAPHY. Bucuresti. [Issued by the Rumanian Academy. In French, German, and Russian]

Vol. 3, no. 1, 1959.

Lazarescu, V. On the new kind of coeloma and paleoecological conclusions on Brachyura, short-tailed crustacea. In Russian. p. 97.

Pavelescu, L. Studies on some eclogites of the Sebes Mountains. In Russian. p. 113.

Stoienescu, S.; Airinei, S. Geophysical contributions to the study of the substratum of the Hateg Basin. In Russian. p. 127.

Stamatiu, M. A study of the influence of saturated solutions of sodium chloride on the mechanical properties of halite (rock salt) from the salt mines in Ocna-Muresului. In Russian. p. 139.

16. TECHNOLOGY

PERIODICALS

PETROL SI GAZE. (Asociatia Stiintifica a Inginerilor si Tehnicienilor din Romania si Ministerul Industriei Petrolului si Chimiei) Bucuresti. [Publication on the oil and natural gas industry issued by the Scientific Association of Engineers and Technicians of Rumania and the Ministry of the Petroleum and Chemical Industries; with Russian summaries. Monthly]
Recurrent features: Innovations and innovators;

Book reviews; Standards and standardization; Activities of the Association.

Vol. 11, no. 7, July 1960.

Tudor, Gh. Geologic works in the petroleum field in the light of the Directives of the 3d Congress of the Rumanian Workers Party. p. 295.

O. A. Gr. Raileanu's Geologia generala (General Geology); a book review. p. 336.

Vol. 11, no. 8, Aug. 1960.

Cocorandu, M. Some considerations of well boring on the terraces in Rumania. p. 348.

Racoveanu, N.; Dumitrescu, I. A device for the teledynamometering of wells during the process of deep pumping. p. 366.

YUGOSLAVIA

16. TECHNOLOGY

CESTE I MOSTOVI. (Društvo za ceste Hrvatske) Zagreb. [Publication on projects, construction, and maintenance of roads and bridges issued by the Roads Society of Croatia. Monthly]

Recurrent feature: Information on personnel.

Vol. 8, no. 8, Aug. 1960.

Hristov, S. Geologic profile in the design of road construction. p. 193.

KEMIJA U INDUSTRIJI. (Društvo kemičara-tehnologa NRH) Zagreb. [Journal on industrial chemistry issued by the Society of Chemical Technologists of Croatia; with English, French, and German summaries. Includes supplements: Fotokemijska industrija, on applied photochemistry; Kemija u poljoprivredi, on chemistry in agriculture; Prerada poliplasta, on the processing of plastics; Sigurnost u pogonu, on industrial safety; Staklo, porculan, keramika, on glass, porcelain, and ceramics. Monthly]

Recurrent features: Brief news from the country; News from the Society.

Vol. 9, no. 3, Mar. 1960.

Rozgaj, S. Examination of clays from the Blatusa deposits. Nemetall. p. N3.

NOVA PROIZVODNJA. (Zveza drustev inženirjev in tehnikov LRS) Ljubljana. [Publication on technology issued by the Federation of Societies of Engineers and Technicians of Slovenia; with English, French, German, Italian, and Spanish summaries. Bimonthly]

Recurrent features: Abstracts from foreign periodicals; Bibliography; Our technical improvements.

Vol. 11, no. 5, 1960.

Ramsak, V. Measuring the density of soil, concrete, minerals, and ores with the gamma-ray scattering method. p. 250.

LIST OF GEOLOGICAL TITLES FROM RUSSIAN PERIODICALS

When the editors of International Geology Review began in Vol. 2, No. 6, June 1960, to list the geologic items appearing in the Monthly Index of Russian Accessions and the East European Accessions Index, it was their intention to list all the available Russian and East European material which should be screened for translation and publication under the AGI Translations Program.

In August 1960, the Library of Congress announced that the Monthly Index of Russian Accessions would no longer carry the translated tables of contents of the periodicals it indexes. The October 1960 issue of IGR (Vol. 2, No. 10), reported this fact and added that an alternative means of providing the lists would be sought.

The AGI Translations Office has recently arranged with the Library of Congress for access to their manuscript translated tables of contents so that this periodicals-listing service may be resumed. The arrangement is such that the titles from periodicals will appear later, and in a different format, than the list of monographic works for any given issue of the Monthly Index, but it is hoped that over a period of time the coverage will be essentially as comprehensive and unbroken as originally planned. Resuming of listing is made with but one month's break in continuity - the contents of periodicals listed in the Monthly Index of Russian Accession for August 1960 (Vol. 13, No. 5) are not available. The periodicals indexed in that issue are here listed by name only. Comprehensive listing resumes with the September issue (Vol. 13, No. 6) and will, we hope, continue unbroken in succeeding months.

It is to be regretted that coverage for each month's Reference Section is now extended over publications of three or more different dates, but it is presumed that researchers and screeners prefer to have material available as quickly as possible. -- M. R.

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Novosibirsk, no. 17, 1956.

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AKADEMIIA NAUK SSSR. Geologicheskii institut. Trudy [ACADEMY OF SCIENCES OF THE U. S. S. R. Geological Institute. Transactions]. Moscow, no. 21, 1960.

AKADEMIIA NAUK URSU, KIEV. Institut geologichnykh nauk. Trudy. Seriya stratigrafii i paleontologii [ACADEMY OF SCIENCES OF THE UKRAINIAN S. S. R. Institute of Geological Sciences. Transactions. Stratigraphical and Paleontological Series]. Kiev, no. 28, 1959. [Microfilm]

AKADEMIIA NAUK SSSR. Komissiiia po izucheniiu chetvertichnogo perioda. Trudy [ACADEMY OF SCIENCES OF THE U. S. S. R. Commission for the Study of the Quaternary Period. Transactions]. Moscow, vol. 15, 1959.

GEOLOGICHESKAIA LITERATURA SSSR. [GEOLOGICAL LITERATURE OF THE U. S. S. R.]. Issued by Vsesoiuznaia geologicheskaiia biblioteka [All-Union Geological Library]. Moscow, no. 2, 1958.

AKADEMIIA NAUK SSSR. Laboratoriia Vulkanologii. Trudy [ACADEMY OF SCIENCES OF THE U. S. S. R. Laboratory of Volcanology. Transactions]. Moscow, no. 17, 1959.

LENINGRAD. NAUCHNO-ISSLEDOVATEL'SKII INSTITUT GEOLOGII ARKTIKI. Informatsionnyi biulleten' [SCIENTIFIC RESEARCH INSTITUTE OF ARCTIC GEOLOGY. Information Bulletin]. No. 13, 1959.

AKADEMIIA NAUK SSSR. Ural'skii filial, Sverdlovsk. Gorno-geologicheskii institut. Trudy [ACADEMY OF SCIENCES OF THE U. S. S. R. Ural Branch. Mining-Geological Institute. Transactions]. Sverdlovsk, no. 41, 1959.

LENINGRAD. NAUCHO-ISSLEDOVATEL'SKII INSTITUT GEOLOGII ARKTIKI. Trudy [SCIENTIFIC RESEARCH INSTITUTE OF ARCTIC GEOLOGY. Transactions]. vols. 91 [Microfilm], 96, 98, 105, 1959.

AKADEMIIA NAUK SSSR. Zapadno-Sibirskii filial, Novosibirsk. Gorno-geologicheskii institut. Trudy [ACADEMY OF SCIENCES OF THE U. S. S. R. West-Siberian Branch. Institute of Mine Geology. Transactions].

REFERATIVNYI ZHURNAL: GEOLOGIIA [JOURNAL OF ABSTRACTS: GEOLOGY]. Issued by Institute nauchnoi informatsii Akademii nauk SSSR [Institute of Scientific Information of the Academy of Sciences of

INTERNATIONAL GEOLOGY REVIEW

the U. S. S. R.]. Moscow, nos. 10-11,
Oct. -Nov. 1959.

SOVETSKAI GEOLOGII [SOVIET GEOLOGY].
Issued by Ministerstvo geologii i okhrany
nedr SSSR [Ministry of Geology and the
Conservation of Mineral Resources of the
U. S. S. R.]. Moscow, vol. 2, nos. 11-12,
Nov. -Dec. 1959.

UZBEKSKII GEOLOGICHESKII ZHURNAL
[UZBEK GEOLOGICAL JOURNAL]. Issued
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of Sciences of the Uzbek S. S. R.] Tashkent,
no. 5, 1959.

13. Science

a. General

PRIRODA [NATURE]. Published by Akademii
nauk SSSR [Academy of Sciences of the
U. S. S. R.]. Moscow, vol. 49, no. 5, May 1960.

16. Technology

h. Mining and Metallurgy

VOPROSY DINAMICHESKOI TEORII RASPRO-
STRANENIIA SEISMICHESKIKH VOLN [PROB-
LEMS OF THE DYNAMIC THEORY OF THE
PROPAGATION OF SEISMIC WAVES]. Issued
by Nauchno-issledovatel'skii institut geofizi-
cheskikh metodov razvedki [Scientific Research
Institute of Geophysical Prospecting]. Leni-
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1. General

a. Scholarly journals

AKADEMIIA NAUK KAZAKHSKOI SSR, Alma-
Ata. Vestnik [ACADEMY OF SCIENCES OF
THE KAZAKH S. S. R. Journal]. Alma-Ata,
vol. 16, no. 2, Feb. 1960.

Gas and oil prospects for the southeastern edge
of the Caspian Depression. P. IA. Avrov
and others. p. 3-10.

Alkamergen' gold-bearing massif of secondary
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Location of metasomatic iron ore deposits in
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Microstructural analysis of salt deposits.
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Color contrasts on the lunar surface in the
visible spectrum. V. G. Teifel'. p. 77-84.

MOSCOW. UNIVERSITET. Vestnik [UNIVERS-
ITY. Review]. Vol. 4, nos. 2-8, 11,
Feb. -Aug., Nov. 1949; vol. 5, no. 12,
Dec. 1950; vol. 6, nos. 3, 5-6, 8, 10, 12,
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AKADEMIIA NAUK SSSR. Ural'skii filial,
Sverdlovsk. Otdel ekonomicheskikh issle-
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OF THE U. S. S. R. Ural Branch. Department
of Economic Research. Transactions].
Sverdlovsk, no. 3, 1958.

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The scope of a regional hydrological survey.
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AKADEMIIA NAUK SSSR. Iakutskii filial,
Yakutsk. Trudy. Seriya geologicheskaya
[ACADEMY OF SCIENCES OF THE U. S. S. R.
Yakut Branch. Transactions. Geological
Series]. Moscow, no. 3, 1959.

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RAZVEDOCHNYI INSTITUT. Trudy [ALL-
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GEOLOGICAL PROSPECTING INSTITUTE.
Transactions]. No. 140, 1959.

Geology and oil potential of the western part
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- Oil and gas potentials of the western part of the West Siberian Plain. G. P. Sverchkov. p. 312-353.
- Combined oil and gas prospecting method to be applied in the western part of the West Siberian Plain. V. G. Korneeva, V. V. Ansimov, L. M. Kravchenko. p. 354-386.
- PALEONTOLOGICHESKII ZHURNAL [PALEONTOLOGICAL JOURNAL] Issued by Akademiia nauk SSSR [Academy of Sciences of the U.S.S.R.]. Moscow, no. 4, 1959.
- Lamarck and Darwin as founders of phylogenetic taxonomy. V. E. Ruzhentsev. p. 5-10.
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- A failure in the publication of paleontological works ("Devonian tetracorals from border areas of the Kuznetsk Basin" by E. Z. Bul'vanker. Reviewed by D. L. Stepanov). p. 149-150.
- Finds of polyzoans and nautiloids in the Ordovician and Silurian of Podolia. G. G. Astrova, F. A. Zhuravleva. p. 154-156.
- UZBEKSKII GEOLOGICHESKII ZHURNAL [UZBEK GEOLOGICAL JOURNAL]. Issued by Akademiia nauk Uzbekskoi SSR [Academy of Sciences of the Uzbek S.S.R.]. Tashkent, no. 6, 1959; no. 1, 1960.
- Classification of ore-bearing comagmatic provinces. V. I. Smirnov. p. 3-12.
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13. Science

a. General

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- Chemical characteristics of certain gypsums in Central Asia. V. M. Glushchenko. p. 139-145.
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- Stratigraphy of the terrigenous part of the lower Carboniferous in the Volga Valley portion of Ul'yansovsk Province (Okhotnich'ya and Barvarovka areas). A. M. Loginova. p. 37-41.
- Systematics of Apsheron Cardiidae. K. A. Astaf'eva. p. 42-49.
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RECENT TRANSLATIONS IN GEOLOGY

A review of the Translation Services

This part of the Reference Section is devoted each month to a listing of the new translations of geologic significance which have become available from sources other than IGR and the established cover-to-cover journals in geology. In doing this we expect to accomplish several purposes:

1) inform geologists of the foreign literature in their field available in translation; 2) provide information necessary to avoid duplication of translation effort, and 3) advise geologists of the activities of the various organizations providing translations, or related services in their field.

Geologists and translators are invited to send announcements of geologic translations which have not been cited by services from which we compile these lists. The submittal of a copy of the translation itself will be construed as an offer for IGR to publish, make copies available at cost of reproduction, and/or turn over to a major translations repository, at our discretion. Suggestions for improving this service are welcomed.

For full names and addresses of sources cited by initials see IGR v. 3, no. 1, pp. 88-89; the following are new initials added since then:

AEC	Atomic Energy Commission Box 68 Oak Ridge, Tenn.
CEA	Commissariat a l'Energie Atomique, France (direct queries to AEC or LC)
RIS	Research Information Service. 40 East 23rd Street New York 10, N. Y.
TB	Telberg Book Company 544 Sixth Avenue New York 11, N. Y.
AIBS	American Institute of Biological Sciences, 2000 P Street, NW Washington 6, D. C.

COVER-TO-COVER JOURNALS OF INTEREST TO GEOLOGISTS

Material in the following translation journals are not included in the subsequent listing of recent translations.

Atomic Energy, published by Consultants Bureau.

Bulletin (Izvestiya) of the Academy of Sciences, USSR, Geophysics Series, published by the American Geophysical Union.

Doklady of the Academy of Sciences of the U. S. S. R., Earth Sciences Sections (Geochemistry, geology, geophysics, hydrogeology, mineralogy, paleontology, petrography, lithology, and permafrost), published by the American Geological Institute.

Geochemistry, published by the Geochemical Society.

Geodesy and Cartography, published by American Geophysical Union.

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Petroleum Geology, published by the Review of Russian Geology.

Problems of the North, published by the National Research Council, Canada.

Soil Science, published by the American Institute of Biological Sciences.

Soviet Geography, selected translations and reviews published by the American Geographic Society.

Soviet Physics: Crystallography, published by The American Institute of Physics.

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Map, 1955, Geological map of deposits containing ground waters in the territory of steppe and forest steppe of Russian craton, 1:3,000,000 (plus two other maps): Moscow. TB, No. 14/List 290.

Map, 1956, Geological map of Tadzhik SSR,

1:1,000,000 (?); sketch geological map of Tadzhik SSR and contiguous areas (to north), 1:8,500,000): Moscow. TB, No. 18/List 290.

Map, 1955, Geological map of Turkmen SSSR, 1:2,000,000: Moscow. TB, No. 15/List 290.

Map, 1955, Geological map of Voliuisik (Yakutsk region) diamond basin, 1:1,500,000: Moscow. TB, No. 16/List 290.

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REFERENCE SECTION

RUSSIAN STRATIGRAPHIC TERMS, STAGE NAMES, AND SYMBOLS

The editors present on the following four pages a compilation by Siemon W. Muller of stratigraphic nomenclature commonly used in Russian geologic literature. It is based primarily on a transliteration and translation of a larger table, produced in color and drafted format. A feature of this compilation which should be of help even to non-Russian-reading users is the symbolic equivalent of stages as used on Russian geologic maps. Researchers interested in other facets of the problem should be aware of:

1. RUSSIAN STRATIGRAPHIC NAMES, by M. K. Elias and Carl C. Branson: Oklahoma Geology Notes, v. 20, no. 11, pp. 287-289, November 1960. This equates the transliteration and translation of many stratigraphic terms with the original Cyrillic version.

2. UNIFORMITY IN GEOLOGICAL TERMINOLOGY AND A NEW SYSTEM OF REGIONAL STRATIGRAPHY: U.S.S.R. Vsesoyuznyye Nauchno-issle. Inst. Kom. Delam Geol., Mater., Pal. i Stratig., 1945. [Materials of the All-Union Geological Institute, Paleontology and Stratigraphy], no. 4, pp. 46-76. This discusses the problem of uniformity in Russian and English stratigraphic terminology. No published translation of this paper is known to exist but an unedited rough translation is available. Its owner would probably release it for publication in IGR if there were sufficient interest shown.

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STAGE NAMES (WITH SYMBOLS) IN THE STANDARD GEOLOGIC COLUMN ADOPTED BY THE GEOLOGICHESKY
 FAKULTET OF THE MOSCOW STATE UNIVERSITY
 (Published as a table by V. V. Drushchits and K. V. Kurdyukov in 1959)*

ERA (GRUPPA) Era (Group)	PERIOD (SYSTEMA) Period (System)	EPOKHA (OTDEL) Epoch (Series)	VEK ILI ZONA (YARUS) Age or Zone (Stage)
C	Quaternary Q	Recent (Holocene) Sovremennyy (Golotsen) ovyy Pozdnechetvertichnyy (Verkhnechetvertichnyy) Srednechetvertichnyy (Srednechetvertichnyy) Rannechetvertichnyy (Nizhnechetvertichnyy) Pleistocene Pleystotsen	Late (Upper) Quaternary Middle Quaternary Early (Lower) Quaternary
	Chetvertichnyy		
O	Neogene N	Pliocene N ₂ Plitsen(ovyy)	Apsheeronsky N _{2ap} Akchagylsky N _{2ak} Kuyalniksky N _{2kl} Kimmeriysky N _{2k} Pontichesky N _{2pn} Pontian
		Miocene N ₁	Meotichesky N _{1m} Sarmatsky N _{1s} Tortoniansky N _{1t} Gelvetiysky N _{1h} Burdigalsky N _{1b} Akvitanskiy N _{1ak}
N	Paleogene Pg	Oligocene Pg ₃ Oligotsen(ovyy)	Khatsky Pg _{3h} Rupelsky Pg _{3r} Lattorfsky Pg _{3l}
		Eocene Pg ₂	Vemmel'sky Pg _{2v} Lediysky Pg _{2ld}
		Eotsen(ovyy)	Lutetsky Pg _{2lt} Ipr'sky Pg _{2i}
E	Paleogen(ovyy)	Paleocene Pg ₁ Paleotsen(nyy)	Tanetsky Pg _{1t} Montsky Pg _{1m}
Z	Neogen(ovyy)		
O	Neogene N		
N	Paleogene Pg		
E	Paleogen(ovyy)		
C	Quaternary Q		

Tertiary - Tretichnyy (Tr)

Kaynozoy'skiy (Kz)

REFERENCE SECTION

C I O Z O S E M	Cretaceous Cr	Late (Upper) Cretaceous Cr ₂	Senon Cr _{2sn}	Datsky	Cr _{2d} Cr _{2m} Cr _{2cp} Cr _{2st} Cr _{2cn} Cr _{2t} Cr _{2cm}	Danian Maastrichtian Campanian Santonian Coniacian Turonian Cenomanian	Senonian Cr _{2sn}
		Pozdnemelavoy (Verkhnemelavoy)					
	Melavoy	Early (Lower) Cretaceous Cr ₁	Neokom Cr _{1nc}	Albsky Aptsky Barremsky Goterivsky Valanzhinsky Berriassky	Cr _{1al} Cr _{1ap} Cr _{1b} Cr _{1h} Cr _{1v} Cr _{1brs}	Albian Aptian Barremian Hauterivian Valanginian Berriasian	Neocomian Cr _{1nc}
		Rannemelavoy (Nizhnemelavoy)					
	Jurassic J	Late (Upper) Jurassic J ₃	Tithon J _{3t}	Verkhny Volzhsky J _{3v2} Nizhny Volzhsky J _{3v1} Kimeridzhsky J _{3km} Oksfordsky J _{3ox} Kelloyevsky J _{3cl}		Upper Volgian Lower Volgian Kimmeridgian Oxfordian Callovian	Tithonian J _{3t}
	Yursky	Pozdenyursky (Verkhneyursky)		Batsky	J _{2bt}	Bathonian	
		Middle Jurassic J ₂ Sredneyursky		Bayossky Aaelnsky	J _{2bj} J _{2a}	Bajocian Aalenian	
		Early (Lower) Jurassic J ₁		Toarsky	J _{1t}	Toarcian	
		Ranneyursky (Nizhneyursky)		Domersky Plinsbakhsky Lotaringsky Sinemyursky Gettangsky	J _{1d} J _{1p} J _{1l} J _{1s} J _{1h}	Domerian Pliensbachian Lotharingian Sinemurian Hettangian	
	Triassic T	Late (Upper) Triassic T ₃ Pozdnetriasovyy (Verkhnetriasovyy)		Retksy Noriyska Karniysky	T _{3r} T _{3n} T _{3k}	Rhaetian Norian Karnian	
M	Triasovyy	Middle Triassic T ₂ Srednetriasovyy		Ladinsky	T _{2l}	Ladinian	
		Early (Lower) Triassic T ₁ Rannetriasovyy (Nizhnetriasovyy)		Anizlysky Oleneksky (= Kampilsky) Indsky (= Seyssky)	T _{2a} T _{1o} T _{1i}	Anisian Olenekian (= Campilian) Indian (= Seisan)	

STAGE NAMES (WITH SYMBOLS) IN THE STANDARD GEOLOGIC COLUMN ADOPTED BY THE GEOLOGICHESKY
FAKULTET OF THE MOSCOW STATE UNIVERSITY (Concluded)
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ERA (GRUPPA) Era (Group)	PERIOD (SYSTEMA) Period (System)	EPOKHA (OTDEL) Epoch (Series)		VEK ILI ZONA (YARUS) Age or Zone (Stage)	
C	Permian P	Late (Upper) Permian P ₂		Tatarsky	P _{2t} Tartarian or Tartarian
	Permian P	Pozdnepermian (Verkhnepermian)		Kazansky	P _{2kz} Kazanian
I	Permian P	Early (Lower) Permian P ₁		Ufimsky	P _{2uf} Ufimian
	Permian P	Rannepermian (Nizhnepermian)		Kungursky	P _{1kg} Kungurian
O	Carboniferous C	Late (Upper) Carboniferous C ₃		Artinsky	P _{1a} Artinskian
	Carboniferous C	Poznekamennougolnyy (Verkhnekamennougolnyy)		Sakmarsky	P _{1s} Sakmarian
Z	Kamennougolnyy	Middle Carboniferous C ₂		Orenburgsky	C _{3o} Orenburgian
	Kamennougolnyy	Srednekamennougolnyy		Gzhelsky	C _{3g} Gzhelian
O	Devonian D	Early (Lower) Carboniferous C ₁		Kasimovskiy	C _{3k} Kasimovian
	Devonian D	Rannekamennougolnyy (Nizhnekamennougolnyy)		Moskovsky	C _{2m} Moscovian
F	Devonian D	Late (Upper) Devonian D ₃		Bashkirsky	C _{2b} Bashkirian
	Devonian D	Pozdne Devonian D ₂		Namyursky	C _{1n} Namurian
L	Devonian D	Middle Devonian D ₂		Vizeysky	C _{1v} Viséan
	Devonian D	Sredne Devonian D ₁		Turneysky	C _{1t} Tournaisian
A	Silurian S	Early (Lower) Devonian D ₁		Famensky	D _{3fm} Fammenian
	Silurian S	Ranne Devonian (Nizhne Devonian)		Fransky	D _{3fr} Frasnian
P	Silurian S	Late (Upper) Silurian S ₂		Zhivetsky	D _{2gv} Givetian
	Silurian S	Pozdne Silurian S ₁ (Verkhne Silurian S ₁)		Eyfel'sky	D _{2e} Eifelian
		Early (Lower) Silurian S ₁		Koblet'sky	D _{1c} Coblenzian
		Ranne Silurian S ₁ (Nizhne Silurian S ₁)		Zhedinsky	D _{1gd} Gedinnian
		Late (Upper) Silurian S ₂		Ludlovsky	S _{2ld} Ludlovian
		Pozdne Silurian S ₁ (Verkhne Silurian S ₁)		Venloksky	S _{1w} Wenlockian
		Early (Lower) Silurian S ₁		Llandovery	S _{1ln} Llandoveryan
		Ranne Silurian S ₁ (Nizhne Silurian S ₁)			

P A L E O Z O I C (concluded)	Ordovician O Ordoviksky	Late (Upper) Ordovician O ₃ Pozdneordoviksky (Verkhneordoviksky)	Ashgilsky Karadoksky	O _{3a} O _{3c}	Ashgillian Caradocian
		Middle Ordovician O ₂ Sredneordoviksky	Llandelsky	O _{2l}	Llandellian
		Early (Lower) Ordovician Ranneordoviksky O ₁ (Nizhneordoviksky)	Llanvirnisky Arenigsky	O _{2ln} O _{1ar}	Llanvirnian Arenigian
			Tremadoksky	O _{1t}	Tremadocian
P A L E O Z O I C (concluded)	Cambrian Cm Kembriysky	Late (Upper) Cambrian Cm ₃ Pozdnekembriysky (Verkhne kembriysky)	No stages established.		
		Middle Cambrian Cm ₂ Srednekembriysky	Maysky Amginsky	Cm _{2m} Cm _{2a}	Mayian Amginian
		Early (Lower) Cambrian Cm ₁ Rannokembriysky (Nizhnekembriysky)	Lensky	Cm _{1l}	Lenian
			Aldansky	Cm _{1a}	Aldanian
PRECAMBRIAN Dokembriysky	Proterozoic Era Pt (Pr ₃) Proterozoyovskaya Era				
	Archean or Archeozoic Era A Arkheyskaya Era				

* Translated and recompiled by Siemon W. Muller

